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AN ETHOLOGICAL INVESTIGATION INTO THE HUSBANDRY OF BULLS

by

TARJEI TENNESSEN

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled An Ethological Investigation Into The Husbandry Of Bulls submitted by Tarjei Tennessen in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

A series of experiments was performed to determine the effect of certain husbandry practices on the behaviour and physiology of bulls and steers. Particular attention was given to cattle transport and to regrouping unfamiliar animals. These may be sources of pre-slaughter stress, which in turn can lead to the condition of dark-cutting in beef carcasses, wherein the meat is unacceptably dark, firm and dry.

1. The effects of social regrouping, time of regrouping relative to slaughter, and group size were examined. Regrouping bulls six or twelve h prior to slaughter led to 14% or 64% dark-cutting respectively. Steers treated in the same manner produced no dark-cutters. Mixing 24 h pre-slaughter led to 74% dark-cutting in one experiment and 52% in another. The effect of group size (seven vs. twenty-one) was not significant. Bulls marketed in stable one-pen groups showed only 2% dark-cutting. Bulls marketed individually, and held overnight at the abattoir, produced no dark-cutters.

2. The behavioural response to regrouping with unfamiliar animals was investigated in 32 bulls and 32 steers kept separately in pens of eight. At ages circa nine, twelve and fifteen months, the cattle were regrouped with strangers. The animals were observed for nine h/day for ten days after regrouping. In both sex-castes, the mixing led to a great deal of aggressive and sex-related behaviour.

Aggressive behaviour was initially much higher in bulls than in steers, but thereafter rapidly decreased. By the tenth day, there was no longer a statistically significant difference between the castes in rate of aggressive behaviour. Mounting occurred much more frequently among bulls than steers, and although the rate of this behaviour declined too, it remained more common among bulls than steers. There was no difference between the two groups in rate of social grooming or of fence chewing ('cribbing'). Overall, differences between bulls and steers increased with age.

3. The behaviour of bulls and steers in groups of 200 was observed in a commercial feedlot. Activity was recorded from 0600 h to 2300 h on eight occasions from January to April. The most prominent difference was mounting, which occurred only rarely among steers, but almost throughout the day among bulls. Bulls also did more bunting, but steers did more gambolling about in the pen. Bulls and steers showed similar daily patterns of fence-chewing, eating and resting. In comparison with the previous experiment, it was found that differences in social behaviour were greater with larger group size. Moreover, the differences in social behaviour between bulls and steers may be due in part to steers' being behaviourally less mature than bulls.

4. Seven groups of six bulls and seven groups of six steers were transported separately by truck for either ten min or two h. Before and after trucking, certain

measurements were taken: body weight, rectal temperature, respiratory rate, serum cortisol, and a chute score. Heart rate was monitored telemetrically in one animal per group. Except for a greater increase in respiratory rate and chute score among steers during the ten min trucking session, there were few differences between the castes. Generally, the reactions of the bulls and steers to trucking were similar and minor. It is concluded that trucking need not be a stressful experience to bulls, and suggested that bulls and steers do not respond very differently to changes in their physical environment.

PREFACE

Castration is an ancient practice in animal husbandry. In Canada, until the last few decades, male cattle (Bos taurus) not intended for breeding purposes were always castrated. These bullocks or steers were raised and fattened on grass, were sometimes used as draught animals, and were typically slaughtered at over three years of age. But with the enormous increase in grain production during this century, and the resulting grain surpluses, a cattle feeding industry emerged. Cattle began to be finished on a grain diet, and weight gains became much more rapid. Cattle raised in this manner began to be, and still are, rarely kept beyond age 18 months.

Recently, the standard procedure of castrating males has been labelled "questionable" (Seideman et al. 1982) and even "archaic" (Berg and Butterfield 1976). However, traditions remain strong, and male cattle are still usually castrated as calves. The practice is typically justified by reference to one or more of several alleged drawbacks to the husbandry of bulls (Kiley 1974). First, there are butchers' prejudices based on the belief that meat from uncastrated males is of poorer quality. For cattle, however, there is now a considerable body of research demonstrating that there is no practical difference between bull and steer meat in eating quality (e.g. Rhodes 1969, Price 1971, Hawrysh et al. 1980). Second, it has in the past been claimed that the performance of castrates is superior to intact males. But

evidence has accumulated showing that based on the ability to produce lean meat, castration inhibits performance: a lower rate of gain (Price and Yeates 1971a), a lower feed conversion efficiency (Price and Yeates 1971b), and a higer percentage of fat in the carcass at a given body weight (Price 1971). Third, it has been suggested that castration is necessary in order to prevent unwanted matings. That risk may once have been a problem, but does not need to be on the modern well-managed farm. To optimize feeding, separation of males and females has long been considered standard practice.

Finally, it has been argued that castration is needed to reduce behavioural problems associated with managing young bulls. Bulls are alleged to be more aggressive and more difficult to handle than steers. Yet the effect of non-castration on behaviour has not received much attention. Bulls and steers are different. Steers produce no testicular androgens. Therefore, their hormone balance is altered, which may alter arousal thresholds (Leshner 1978). However, little is known about the situational contexts in which the two sex-castes actually exhibit different behaviours or states of arousal. In other words, the problem of how, and under what circumstances, androgens (or other hormones) are relevant to the behavioural responses of farm animals is still poorly understood.

The agricultural theme of this thesis is the husbandry of bulls. As my starting point I have chosen one problem

associated with bull husbandry: the condition referred to as "dark-cutting beef". Though its effect is for the most part only cosmetic, dark-cutting beef is an economically important phenomenon. Dark-cutting carcasses are darker than the bright red colour preferred by supermarket shoppers, and are therefore not worth the top price. Bulls are particularly likely to dark-cut, and because of that, a farmer may lose money marketing bulls. Although the dark colour can be explained metabolically, the effect is thought to be largely the result of certain stressful experiences the animals have had prio to slaughter. To understand those experiences, it is necessary to understand the behaviour of bulls and how it differs from the behaviour of castrates. More specifically, it means understanding how bulls respond to the typical handling, housing and general management that beef cattle are exposed to while they're growing and especially during the time immediately before slaughter.

Therefore, my objectives in this study have been:

1. to investigate the occurrence of the dark-cutting phenomenon in cattle (especially bulls) and to determine what husbandry conditions predispose cattle to dark-cut, and

2. to determine how bulls and castrates respond behaviourally to those husbandry conditions.

My presupposition has been that there are two sets of circumstances (broadly defined) that are potentially stressful, and that may affect bulls and castrates differently:

1. disruption of their social environment: unacquainted cattle are often brought together either at some time during their stay in the feedlot, or during the marketing process.

2. disruption of their physical environment: marketing cattle usually means transport by truck or rail to a public stockyards or directly to an abattoir. The animals are removed from the environment they know, to one they don't know.

Newness tends to be alarming to animals. Their awareness and vigilance become heightened (Geist 1978). How bulls and castrates respond to each of these situations will determine the degree of emotional trauma felt by the animal. I have studied each situation separately.

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I. INVESTIGATIONS OF DARK-CUTTING IN BEEF CATTLE

INTRODUCTION

In 1979 a questionnaire was sent to senior scientists in meat research laboratories in nineteen countries (Tarrant 1981). The questionnaire dealt with the phenomenon of 'dark-cutting' in the beef industry, a condition wherein beef carcasses are unacceptably dark, firm, and dry. In the 1979 survey, estimates of the incidence of dark-cutting varied: 1-5% for steers and heifers, 6-10% for cows, and 11-15% for young bulls. It was a condition that occurred in all countries surveyed.

Generally, the condition is thought to be caused by stress 8-48 hours before slaughter (Lewis et al. 1962) such as from deprivation of food or water, sudden changes in temperature, physical exhaustion or emotional trauma. Biochemically, the changes in the meat which cause dark-cutting are known and understood (Lawrie 1974, Hood and Tarrant 1981). Secretion of the hormone adrenalin which occurs during stress, begins a chain of reactions which ultimately results in the production of a less acid meat than normal, which is darker, stickier and probably does not keep as well as normal meat. However, there is evidence that dark-cutting beef may be more tender than normal, and consumer panel tests suggest that eating quality characteristics are probably unaffected (Hawrysh et al. 1983). Despite this, dark-cutting will automatically alter

the grade of a beef carcass in Canada, since dark-cutters cannot grade A (the grade which currently attracts the highest price). Bull carcasses are particularly likely to dark cut (Duchesne 1978).

In this chapter, three experiments are discussed. Each deals with a facet of pre-slaughter management and its influence on the frequency of dark-cutting beef. Experiment 1 focuses on the central problem of regrouping unacquainted bulls. Establishing new social relationships may be an emotionally stressful experience. In Experiment 2, bulls are compared to steers, and each is evaluated under two management options: regrouping the evening before slaughter (at a time of day when cattle are normally quiet), and regrouping the morning of slaughter. Experiment 3 examines another management strategy, a penning arrangement that makes use of a high perimeter:area ratio in the holding pen to try to reduce the number of agonistic interactions and hopefully, the occurrence of dark-cutting.

A. EXPERIMENT 1. AGONISTIC INTERACTIONS AMONG UNACQUAINTED BULLS AS A CAUSE OF DARK-CUTTING BEEF

In order to reduce the incidence of dark-cutting beef, signigicant pre-slaughter stressors must be kept to a minimum. Social stressors may be important contributors to the overall stress resonse of the animals. And at least two sets of circumstances surrounding the trucking and holding of bulls prior to slaughter may lead to social stress:

marketing bulls in large groupings, or marketing bulls in groups of individuals unacquainted with one another. Therefore, the purpose of this experiment was to investigate the effects of group size and of social regrouping on the incidence of dark-cutting.

MATERIALS AND METHODS

The experimental animals were 124 cross-bred yearling bulls born and raised at The University of Alberta Ranch, Kinsella, Alberta. Of these, 112 bulls were randomly distributed, at about twelve months of age, to ten pens of seven bulls each and two pens of 21 bulls each. The stocking density was similar in each pen. The bulls remained in these allotments for 12-14 weeks until consigned to the abattoir. The bulls were marketed in eight shipments over a four week period. The animals were sent in either small groups (seven bulls) or larger groups (21 bulls), and as unmixed groups (all bulls from the same pen) or as mixed groups (bulls brought together from several pens). The scheme, shown in Figure I.1, achieved a fully replicated 2 X 2 comparison of marketing in large versus small and mixed versus unmixed groups.

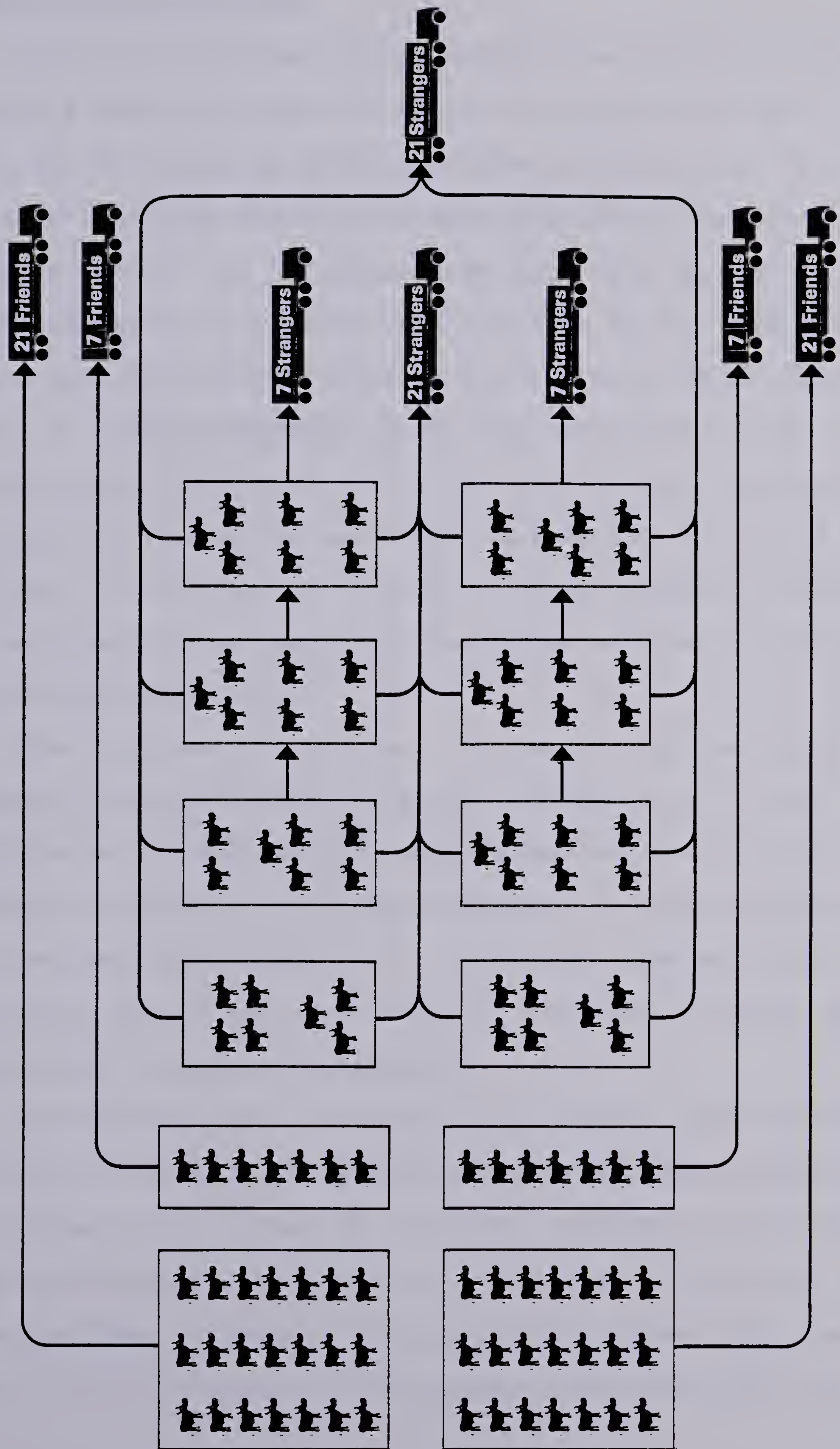
Each lot of bulls was trucked to the abattoir the morning before slaughter. Transport from Kinsella to Edmonton (two hours over a distance of 160 km) was done by commercial trucker. In order to see how the animals behaved during the trucking, I rode in the back of the truck with

the cattle. But because it was not possible to see all the bulls in this crowded situation, only general note on their overall behaviour were recorded.

At the abattoir the bulls were held overnight without feed or water in a 7.3 m X 8.2 m pen before slaughter. During that time, I observed the bulls for two hours immediately after arrival in the late morning, for one hour during the afternoon, again during the early evening, and for a final one hour period before slaughter the next morning. The number of bunts (where the head of one bull made contact with any part of the body of another), and mounts was recorded for 30 minutes during each of the four observation periods. Of the remaining twelve bulls, seven were individually shipped to the packing plant at weekly intervals and were penned alone overnight before slaughter. Five bulls were left-overs, and were included simply to ensure that the last of the individually shipped bulls was not penned by itself during the final week at the University Ranch.

Following slaughter and overnight cooling, the carcasses were colour rated 'bright' or 'dark' by Agriculture Canada Graders. The percentage of animals graded 'dark' per shipment was transformed using the arc sin transformation. The data were analyzed using analysis of variance. Sources of variation were mixing (1 df) and size of group (1 df).

Figure I.1. Experimental marketing scheme: Lots consisted of either 7 or 21 bulls from a single pen (friends) or regrouped from several pens (strangers) as illustrated.


21 Strangers
21 Friends
7 Friends
7 Strangers
21 Strangers
7 Strangers
7 Friends
21 Friends

RESULTS AND DISCUSSION

Bulls in the mixed groups remained active during the entire 2 hour trip from the ranch to the packing plant. Mounting and fighting behaviour occurred regularly. The pattern continued during overnight penning at the abattoir. This is contrary to information on pigs (Sus scrofa) in mixed shipments which have been found to settle down after being held for about an hour at the abattoir (Moss 1978). Bulls in unmixed shipments were much more calm during trucking. Most stood still for the entire trip, and seemed to position themselves such that they were not oriented face to face. At the abattoir, bulls in mixed shipments engaged in more bunting and mounting than those shipped in unmixed groupings (Table I.1).

The observed differences in behaviour between mixed and unmixed groups coincided with major differences in the occurrence of dark-cutting. Bulls from the mixed groups showed a significantly higher incidence of dark-cutting than the unmixed bulls (Table I.2). Load size, whether seven or 21 bulls, had no important effect. There was no dark-cutting among bulls shipped individually.

The lack of dark-cutting in the unmixed loads could be a result of either the absence of agonistic encounters or the presence of a group of 'friends' shielding each bull from the potential stress of an unfamiliar environment. The results from the seven individual bulls suggest that they were little disturbed by the strange environment *per se*.

Table I.1. Mean number of bunts and mounts per dyad for bulls in large (21) or small (7) groups drawn from several pens (mixed) or single pens (unmixed). Recorded during four 30 min observation sessions while bulls were held at an abbatoir. (mean±SE)

	LARGE LOADS (21 bulls)	SMALL LOADS (7 bulls)
MIXED		
Mount	0.31±.04	1.53±.31
Bunt	0.47±.02	1.90±.15
UNMIXED		
Mount	0.03±.01	0.13±.04
Bunt	0.05±.01	0.23±.06

Table I.2. The incidence of dark cutting among the carcasses of young bulls shipped in large groups (21) or small groups (7) or individually, and taken either from several pens (mixed) or single pens (unmixed) in the feedlot.

	LARGE LOADS	SMALL LOADS	INDIVIDUALLY SHIPPED
MIXED			
Number	42	14	—
Dark-Cutters	29 (69%)	12 (86%)	
UNMIXED			
Number	42	14	7
Dark Cutters	1 (2%)	0 (0%)	0 (0%)

Effect of Group Size $p>0.05$

Effect of Mixing $p<0.01$

Therefore I suggest that the presence of strange bulls caused the major trauma in shipping and holding, rather than the absence of familiar bulls or the novelty of the truck or the packing plant environment. Mixing bulls before slaughter is thus a primary cause of dark-cutting resulting presumably from both psychological and physiological stressors.

B. EXPERIMENT 2. THE EFFECT OF CASTRATION AND TIME OF MIXING ON THE INCIDENCE OF DARK-CUTTING IN BEEF CATTLE

In Experiment 1 it was established that mixing yearling bulls 24 h before slaughter led to a large increase in the incidence of dark-cutting carcasses. So mixing strange animals should be avoided. But regrouping may at times be unavoidable. Therefore, it would be advantageous if regrouping could be done in such a way that aggressive behaviour would be less severe. One strategy would be simply to regroup the cattle for shorter periods of time before slaughter. Another strategy would be to take advantage of the normal circadian cycle of activity shown by cattle. It has been found that steers (Hughes and Reid 1951), and bulls and steers (Christopherson 1973) in feedlots are much less active during late evening and early morning than at other times. For marketing purposes, can the mixing be done more safely late in the evening when the animals are normally settling down for the night? If the animals are allowed to get used to each other during a period of typically low activity, the fighting which presumably leads to

dark-cutting may be reduced. Is this management strategy an improvement over simply mixing the cattle the day of slaughter?

MATERIALS AND METHODS

The experimental animals were 28 bulls and 28 steers (castrated at approximately two months of age). All cattle were mixed breed, born and raised at The University of Alberta Ranch, Kinsella, Alberta. At the time of the experiment, July 1982, the animals were 15-16 months old. Both bulls and steers had been penned in the feedlot in groups of eight since weaning at age 5-6 months (one animal from each of these pens was left out of the study). During that time they had been fed, <u>ad libitum</u>, a high energy diet consisting mainly of barley and oats. The sex-castes were kept separate throughout the experiment.

Before being shipped to the packing plant, the animals from different pens were recombined into lots of seven in such a way that they met either five or six strangers with which they had not interacted for six months. Half the animals were regrouped at 2300 h (12 hours before slaughter), the others were regrouped at 0500 h (6 hours before slaughter). This arrangement achieved a fully replicated 2 X 2 comparison of mixing the night before versus the morning of slaughter and bulls versus steers. The cattle were marketed in two shipments of four lots each, at one week intervals. Transport for the 160 km trip from

Kinsella to an Edmonton abattoir was done by commercial trucker. Cattle were slaughtered within one hour of arrival at the plant.

Following slaughter and overnight chilling, the carcasses were rated 'bright', or 'dark' by Agriculture Canada Graders.

RESULTS AND DISCUSSION

This experiment revealed a fundamental difference in the susceptibility of bulls and steers to the dark-cutting condition. Dark-cutting occurred only among the bulls (Table I.3). Regrouping the bulls at night (12 h before slaughter) was not a successful strategy in reducing the incidence of dark-cutting. And it seems that mixing bulls as little as 6 h before slaughter can still result in some dark-cutting among bulls. On the other hand, regrouping steers even 12 h before slaughter did not induce any dark-cutting. The results of this experiment give little reason to think that there is any beneficial effect from regrouping bulls at night. The incidence of dark-cutting (64%) approaches the level achieved when bulls were mixed 24 h prior to slaughter (73%) (results of Experiment 1).

It should be noted that at latitude 53° N in July, 2300 h is only dusk, and 0500 h is slightly after dawn. Because of the long period of daylight, the cattle may have been more active than they would have, for example in winter, when both 2300 h and 0500 h fall during darkness.

Table I.3. The incidence of dark-cutting among bulls and steers regrouped twelve hours or six hours before slaughter.

	Regrouped at night 12 hours before slaughter	Regrouped in morning 6 hours before slaughter
BULLS		
No. of animals	14	14
Dark-cutters	9	2
	(64.3%)	(14.3%)
STEERS		
No. of animals	14	14
Dark-cutters	0	0
	(0%)	(0%)

C. EXPERIMENT 3. "PERIMETER EFFECT" PENNING ARRANGEMENT AND THE INCIDENCE OF DARK-CUTTING

In Experiment 2 it was established that evening mixing (12 hours before slaughter) was not a successful strategy to reduce the occurrence of dark-cutting in bulls, compared to merely mixing the animals the morning of slaughter. In fact, mixing 12 h before slaughter (even at night) is almost as harmful as mixing 24 h before slaughter (results of Experiment 1). It was also found that steers did not exhibit any dark-cutting even when allowed to interact with strangers for 12 h before slaughter. A simple solution for bulls seems to be never mixing strange cattle immediately before slaughter. But regrouping cattle before slaughter is often unavoidable. Bulls are often regrouped at the feedlot based on estimated carcass finish. Or, if small lots of cattle are trucked to an abattoir, cattle from different farms may be penned together overnight prior to slaughter, or in extreme cases, for as long a weekend.

Can the behaviour of cattle, specifically bulls, be controlled so as to reduce the stressfulness of meeting unfamiliar animals? Tranquilizers (Venediktova et al. 1977) and 'anti-androgen substances' (Andreae et al. 1981) have not been successful in reducing aggressive behaviour among unacquainted bulls. In any case, such treatment would not be possible in animals bound for slaughter nor feasible on a large commercial scale. However, penning arrangements may provide a commercially feasible, non-pharmacological way of

modifying the social behaviour of cattle. Stricklin (1975) speculated that the perimeter of a pen, the fenceline, is attractive to animals and gives a feeling of security and extra space. It is largely on this basis that he recommends triangular pens for housing cattle, because triangles have a greater perimeter:area ratio than squares. Long narrow pens also provide a higher perimeter:area ratio, and Kilgour (1976) reported that some New Zealand farmers use narrow, oblong yards to house bulls. Supposedly, this decreases the frequency of undesirable social behaviour. Grandin (1979) held 17 4-H steers (unfamiliar with each other) overnight in a narrow pen before slaughter. There was no dark-cutting among these animals. But neither was there a control to which the 'narrow-penned' steers could be compared.

The purpose of this experiment was to find out whether a penning arrangement that increased the amount of perimeter space and that provided a partial barrier for subordinate animals, could lower the frequency of agonistic interactions and reduce the incidence of dark-cutting carcasses.

MATERIALS AND METHODS

Again, the experimental animals were crossbred beef bulls born and raised at the University of Alberta Ranch, Kinsella, Alberta. Forty six bulls, aged from 15-17 months were used. The animals were marketed in three shipments: two lots of 16 bulls each and one of 14. On the morning of shipping, bulls from eight different pens were combined for

trucking to the packing plant. As in the previous experiments, transport was done by commercial trucker. At the plant, the bulls were held overnight before slaughter the next morning. Half of the bulls were kept in a normal rectangular pen (perimeter: 26.8 m, area: 45.0 m^2). The remaining bulls were held in an area made up of two smaller pens, with a gate left open between them. These pens had a larger perimeter:area ratio (perimeter: 37.8 m, area: 46.5 m^2), which was intended to make it easier for the bulls to maintain individual distance (Hediger 1964) by taking advantage of the phenomenon of perimeter effect (Stricklin 1975). About two m of fence formed a partial barrier within the long narrow pen (actually two pens combined). It was thought that this might also provide an opportunity for some bulls to hide from others. The number of bunts and mounts were recorded during 30 minute periods after arrival at the plant and before slaughter the next morning. Twenty four hours after slaughter, the carcasses were graded by Agriculture Canada Graders, and the pH of the rib-eye muscle of the right hindquarter was measured by personnel from the Dept. of Foods and Nutrition, University of Alberta.

Differences in the frequency of mounting and bunting were tested by the Mann-Whitney U Test (Hull and Nie 1981). The distribution of dark cutters was analyzed by the chi-square test of independence, and pH differences were analyzed by the Student's T-test (Nie et al. 1975)

RESULTS

The experimental penning procedure did not significantly reduce the frequency of agonistic or sexual behaviour within the group (Table I.4). And there was no obvious sign that bulls stayed close to the fenceline as an attempt to avoid interacting. However, the somewhat lower mean rates of these behaviours among the experimentally penned bulls may be biologically real, and may have been statistically significant if greater numbers of animals had been tested. Table I.5 shows that there was no significant difference in the occurrence of dark-cutting carcasses or in the 24 h post-mortem carcass pH between the control group held in square pens, and the experimental groups held in pens with more perimeter space. The greater amount of perimeter fence space produced no identifiable effect on the incidence of dark-cutting.

D. GENERAL DISCUSSION

All three experiments suggest a certain unavoidability of aggressive behaviour among unacquainted bulls, and of a consequently higher occurrence of dark-cutting carcasses. Strategies that were used to reduce the frequency of dark-cutting (late night regrouping, 'perimeter effect' penning) were not successful. The imperatives of social behaviour exerted their effect. And to the social upheaval of regrouping was added the drastic change in physical environment from feedlot to truck to abattoir. Both of these

Table I.4. Mean number of bunts and mounts per pen of bulls held in either a square pen or a long-narrow pen. Based on two 30 min observation periods while bulls were held overnight at an abattoir.

	Mount	Bunt
Square Pen	42.8±3.2	44.9±2.7
Long-narrow Pen	36.8±4.6	38.8±3.8
	p=0.191*	p=0.177*

* Mann-Whitney U Test (Hull and Nie 1981)

Table I.5. Incidence of dark-cutting, and 24 h post-mortem pH, in bulls held overnight in either a square pen or in a long narrow pen with a greater perimeter:area ratio.

	Square Pen	Long-narrow Pen
Number	23	23
Dark-cutters **	13 (57%)	11 (48%)
pH (Mean±S.E.) *	6.09±0.99	5.99±0.88

** chi-square=0.087, df=1, p=0.77

* t=0.72, df=42, p=0.48

potentially stressful changes may be involved in all the experiments: the agonistic interactions among the bulls and the moving of the bulls into an unfamiliar environment. In the mixed groups of bulls either or both of these stressors could have caused the high incidence of dark-cutting.

Regrouping bulls leads to a greatly increased level of agonistic behaviour and these interactions in addition to being stressful (McCready, 1980), may lead to fatigue. As Hedrick (1965) pointed out, exhausting exercise has the immediate effect of reducing muscle glycogen. So the severity of the stress due to forced interaction is probably a result of the combination of acute psychological trauma and physical exhaustion. Louch and Higginbotham (1967), using mice, found that the psychological stress of defeat after fighting was important in eliciting adrenocortical activity. Brain (1971) who also worked with mice, reported that defeated mice showed an increased adrenocortical activity not evident in victorious animals. And Bronson and Eleftheriou (1965) found that mice that had previously experienced defeat had a greater adrenal response to the presence of a trained fighting mouse than did mice without such experience.

Assuming that these psycho-physiological mechanisms apply to cattle, we are led to believe that socially subordinate animals may suffer the most and therefore be most likely to dark cut. Grandin (1978), working with steers, found that dark-cutters tended to be the very heavy

and the very light animals. One possible explanation is that both very high and low ranking animals engage in a disproportionately high number of agonistic interactions during the 24 h following regrouping. Among high ranking animals which are predominantly winners in fighting encounters, the emotional trauma of regrouping may be less than among those animals that lose.

Hucklebridge and Nowell (1974) reported that adrenalin release was stimulated in mice under certain circumstances such as actual fighting, but not by more general "psychological" stimuli. This may account for the absence of dark cutting among individual and non-mixed shipments. With these animals, only the emotional/physical trauma of fighting and otherwise interacting with unfamiliar bulls was removed.

It is likely that introduction into a totally foreign environment results in at least an elevated state of arousal (Taylor 1978). And it has been suggested that merely seeing strange or unfamiliar animals results in stress to cattle (McCready 1980). Yet on the basis of my results it seems that the so called psychological stressors of transport and confinement in a foreign environment (the packing plant) are not sufficient to induce dark-cutting in young bulls. The physical exercise and/or psychological trauma of agonistic encounters seems to be necessary.

The length of time that vigorous aggressive and sexual behaviour must take place before dark-cutting will be seen

post-mortem is a function of energy stores (glycogen) and rate of energy use. But even in the absence of truly exhausting exercise, dark-cutting can occur (see Appendix 1 for further explanation of the metabolic processes involved), and evidence is now appearing which suggests that this may be due to an inability to use other energy stores (e.g. free fatty acids), thereby accelerating glycogen depletion in liver and muscle (Lister and Spencer 1981). Why this may happen in psychologically stressed animals is not known. Nevertheless, the data from the second experiment performed here demonstrates that just 6 hours of presumably stressful social interaction is enough to give a higher rate of dark-cutting in bulls. It is also clear that steers are different from bulls in this respect. Just how they are different (behaviourally) is not clear, but that issue is explored more fully in the next chapters.

II. EFFECT OF REGROUPING ON THE INTERACTIONS OF YOUNG BULLS AND STEERS

INTRODUCTION

Good husbandry is essential to profitable production. And good husbandry of any livestock, including bulls, requires a sound knowledge of their behaviour. In the previous chapter, it was shown that proper management of bulls was critical to the prevention of the dark-cutting condition. Evidence was given that the behavioural interactions of unacquainted bulls were largely responsible for the dark-cutting. Steers did not produce dark-cutters as readily as did bulls, which may mean that steers do not behave like bulls. Although information on the general behaviour of bulls has been available for some time (see Sambraus 1979), data comparing the behaviour of bulls and steers are rare, and have only recently become available. Christopherson (1973) observed yearling bulls and steers in groups of six or seven. He estimated that steers spent only one third as much time bunting and mounting as bulls. In Australia, mixed sex herds of bulls and steers on pasture were studied, and it was reported that behavioural differences between bulls and steers were significant only after age 14 months (Hinch et al. 1983). However these cases dealt with well-established groups of cattle where animals were familiar with each other.

One common management tool is to regroup livestock to minimize under and overstocking in the pens, or prior to slaughter, on the basis of estimated carcass finish. But as was shown in the previous chapter, mixing bulls which are unfamiliar with each other led to a high incidence of the dark-cutting condition in carcasses (see also Price and Tennessen 1981). Regrouping animals unfamiliar with each other presumably results in social stress which may in turn be the prime agent that induces dark-cutting. How bulls and castrates differ in their response to regrouping may be a clue to why the dark-cutting condition is more common among bulls than among steers. This study was designed to investigate the effect of regrouping on the frequency of various interactions among bulls and steers.

MATERIALS AND METHODS

Sixty-four male calves born at The University of Alberta Ranch at Kinsella were divided into two groups balanced with respect to breed of dam and breed of sire. Calves in one group were castrated at age seven to ten weeks. The 32 bull and 32 steer calves were randomly assigned into pairs such that there were 16 pairs within each sex-caste. Each pair of calves remained together as one unit throughout the experiment. After weaning, at age 20 to 23 weeks, pairs of bull and steer calves were assigned to one of eight 6.15m X 9.1m pens. Each pen held eight animals

(four pairs of animals per pen); bulls and steers were housed in separate pens. Throughout the post-weaning period, the animals were fed ad libitum, a high energy, low roughage diet consisting primarily of barley and oats.

At ages circa 9, 12 and 15 months (January, April, July 1982), the pairs of calves were regrouped into new combinations. The regrouping was done is such a way that each pair of animals met three unfamiliar pairs. That is, at each mixing every animal met six strangers. For 10 consecutive days after regrouping, each of the eight pens was observed for 22.5 minutes three times per day: morning (0900-1200 h), afternoon (1300-1600 h) and evening (1800-2100 h), for a total of nine observation h per day. Behaviours, all occurrences of which were recorded, are summarized in Table II.1. See also Plates II.1 to II.4. The cumulative number of minutes spent fighting during each observation period was recorded, and at the beginning of each observation period, the number of animals standing up and lying down was recorded. Observations were made from a parked truck. Ambient temperature was recorded at the beginning of each observation period.

After the completion of the study, a blood sample (via the jugular vein) was collected from each animal. Circulating levels of thyroid hormones (thyroxine and triiodothyronine), which may be useful indeces of general metabolic activity (Archer 1979), were assayed. After the animals were slaughtered, adrenal glands were collected and

Table II.1. Description of Recorded Behaviours.

SEXUAL BEHAVIOUR	
Mount	One animal mounts another, from any angle.
Chinrest	One animal places its chin on the hips of another, often accompanied by sideways licking motion.
Flehmen	Lip-curl response, preceded by licking or smelling the urine of another animal. Probably functions to enchance olfactory perception.
AGGRESSIVE BEHAVIOUR	
Headbunt	Two animals bunt their heads together and push.
Bunt	One animal bunts another, usually to shoulder or flank.
Threat	A Bunt or Headbunt is begun, but no contact is made.
'Fight'	The time spent engaging in headbunts.
OTHER	
Grooming	One animal licks another around face and neck. Assumed to be amicable.
Cribbing	Animal chews fencing or other property.

weighed. Adrenal weight has been used as an index of social stress in mice (Archer 1969).

The average frequency of various behaviours among age-sex groups were analyzed by least squares analysis of variance. Chi-square tests were used to compare the distribution of behaviours, and correlation analyses were used to examine the relation between ambient temperature and behaviour. Finally, discriminant function analysis (Nie et al. 1975) was used to separate age and sex-caste components of aggressive and sexual behaviour.

RESULTS AND DISCUSSION

Both bulls and steers fought when introduced to animals with which they were not familiar. But at all ages, bulls performed more aggressive acts and spent more time fighting than did steers (Table II.2 and II.3). For both bulls and steers, the average time spent fighting during observation periods decreased from a high at age nine months, but the overall frequency of aggressive contests peaked at twelve months. The average duration of each contest was therefore considerably less at twelve months than at nine. Behaviour change across ages may also be influenced by the animals' previous experiences with mixing. Average ambient temperatures during the sessions were: January -16.6 ± 0.4 °C, April 9.7 ± 0.3 °C, July 20.3 ± 0.3 °C. High ambient temperature in July may have accounted for the decreased fighting behaviour at age 15 months. A negative correlation (across

Plate II.1. One bull is resting its chin on the hips of another. This behaviour often precedes mounting.

Plate II.2. Flehmen, or lip-curl response performed by one bull after licking the urine of another.

Plate II.3. Headbunt performed by two bulls.

Plate II.4. Mounting of one bull by another.

Table II.2. Body weight and average occurrence of agonistic activities (per pen per hour) during observation periods for 10 days after regrouping (Means ± SE).

	Bunt	Head Bunt	Threat	Fighting (min)	Body Weight (kg)
9 months					
BULLS	6.5 ± 0.9	11.2 ± 1.4	5.0 ± 0.5	7:45 ± 1:08	299 ± 6.4
STEERS	4.7 ± 0.6	6.8 ± 1.0	2.2 ± 0.3	1:59 ± 0:23	290 ± 6.1
12 months					
BULLS	9.7 ± 1.0	13.4 ± 1.5	5.2 ± 0.5	3:43 ± 0:30	407 ± 8.0
STEERS	5.3 ± 0.7	5.2 ± 0.6	5.3 ± 0.6	1:25 ± 0:13	386 ± 7.2
15 months					
BULLS	6.1 ± 0.9	6.1 ± 0.9	4.5 ± 0.7	0:58 ± 0:10	526 ± 9.9
STEERS	2.1 ± 0.3	1.1 ± 0.2	2.3 ± 0.4	0:08 ± 0:02	491 ± 8.7
Effect of sex	***	***	**	***	**
Effect of age	**	***	**	***	***
Age x sex	NS	**	NS	***	***

NS P>0.1
* P<0.1
** P<0.05
*** P<0.01

Table II.3. Average occurrence of sexual behaviour, cribbing and grooming (per pen per hour) during observation periods for 10 days after regrouping (Means ± SE).

	Mount	Chin Rests	Flehmen	Cribbing	Grooming
9 months					
BULLS	6.9 ± 1.2	4.8 ± 0.7	3.3 ± 0.4	0.4 ± 0.14	0.7 ± 0.17
STEERS	0.3 ± 0.1	0.8 ± 0.2	0.4 ± 0.1	0.3 ± 0.09	0.6 ± 0.13
12 months					
BULLS	12.3 ± 1.5	7.9 ± 0.7	4.9 ± 0.5	0.4 ± 0.11	7.6 ± 0.13
STEERS	0.6 ± 0.1	1.2 ± 0.2	0.4 ± 0.1	1.2 ± 0.17	1.7 ± 0.20
15 months					
BULLS	3.9 ± 0.8	5.4 ± 0.9	2.8 ± 0.4	1.5 ± 0.30	1.2 ± 0.25
STEERS	0.1 ± 0.08	0.1 ± 0.06	0.1 ± 0.05	0.7 ± 0.18	1.1 ± 0.22
Effect of sex	***	***	***	NS	NS
Effect of age	**	*	**	***	NS
Age x sex	*	NS	*	***	NS

NS P>0.1
* P<0.1
** P<0.05
*** P<0.01

all ages) was found between amount of time spent fighting and ambient temperature for both bulls and steers ($r=-0.33$ and $r=-0.29$ respectively, $p<0.01$).

Figures II.1, II.2 and II.3 show the reduction in aggressive behaviours at about 9, 12, and 15 months of age, over the ten day period after regrouping. At all ages bulls were more aggressive than steers. The initial level of aggressive behaviour of bulls was in all cases at least twice that of the steers. But during the succeeding days the number of aggressive acts fluctuated, particularly among the bulls. Some of the fluctuation may have been due to short-term fatigue. Yet over the entire ten day period, there was a decrease in aggressive behaviour in both groups, and by the last two days there was no statistically significant difference in the rate of occurrence of aggressive behaviours between the bulls and steers.

The rate of sexual behaviour decreased after regrouping, yet bulls maintained a much higher level of mounting than did the steers (Figures II.4, II.5 and II.6). It is also clear that whereas regrouping seemed to have been a stimulus for sexual investigation among bulls, it had no such effect on steers. At all ages, bulls performed significantly more mounting and other sexual acts than did steers. Among bulls and steers, sexual behaviour was performed more frequently at twelve months than at nine or fifteen. Although sex related behaviour decreased over the ten day period, bulls retained a significantly higher

Figure II.1. The mean hourly occurrence of aggressive acts (headbunts+bunts+threats) among bulls and steers for 10 days following regrouping: Age circa 9 months, January 1982. Data collected between 0900 h and 2100 h.

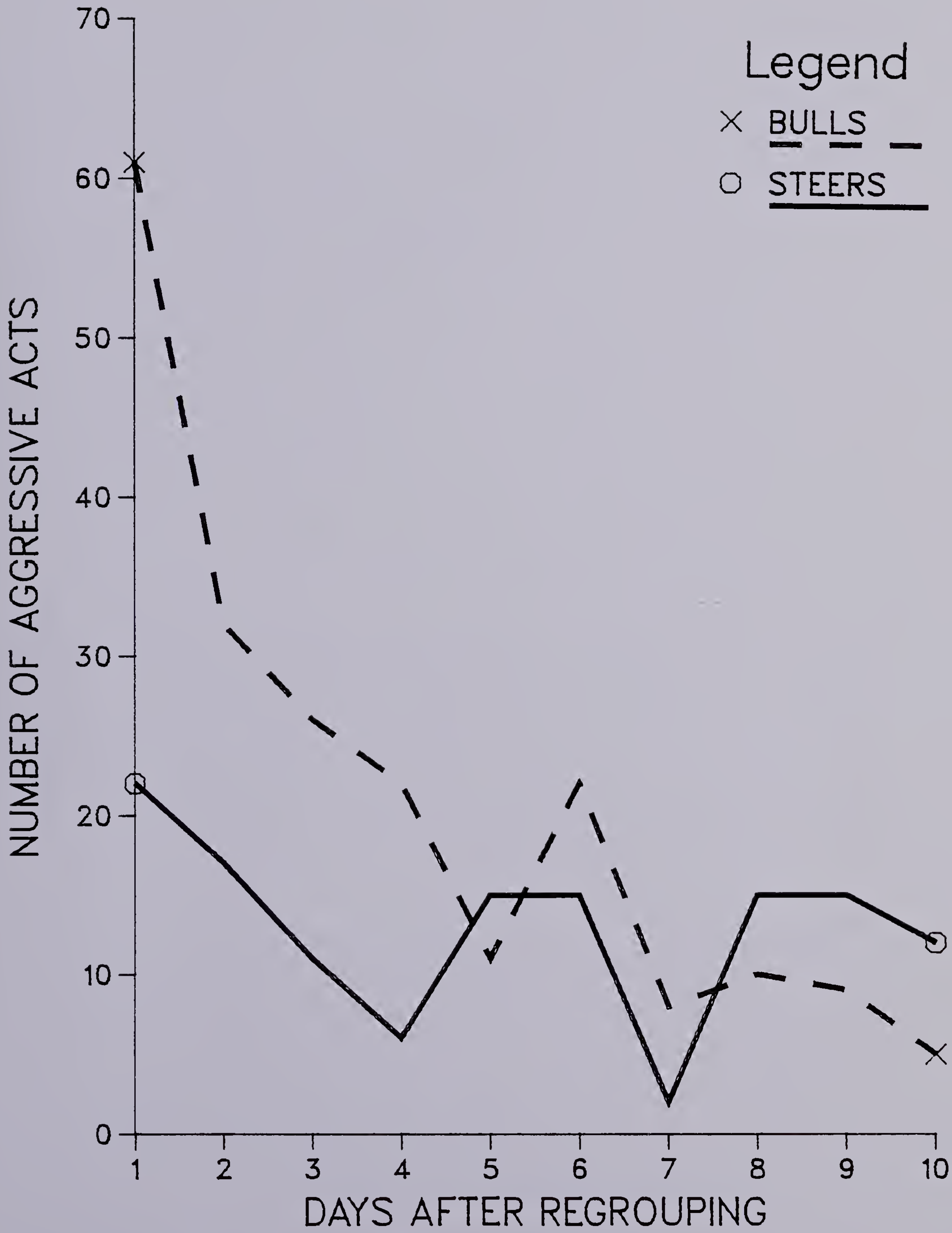
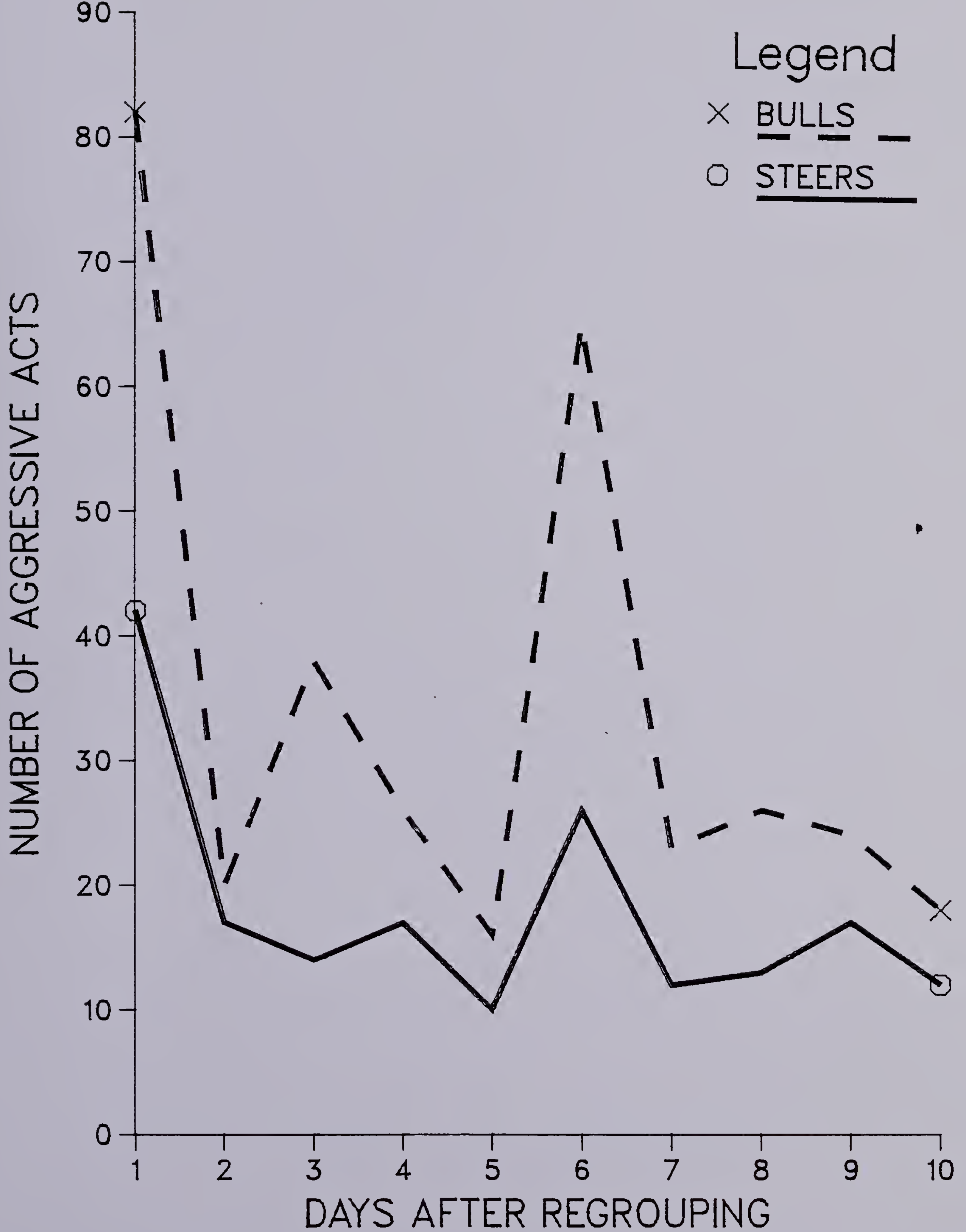

Legend
BULLS
STEERS
NUMBER OF AGGRESSIVE ACTS
0
10
20
30
40
50
60
70
1
2
3
4
5
6
7
8
9
10
DAYS AFTER REGROUPING

Figure II.2. The mean hourly occurrence of aggressive acts (headbunts+bunts+threats) among bulls and steers for 10 days following regrouping: Age circa 12 months, April 1982. Data collected between 0900 h and 2100 h.



Legend
BULLS
STEERS
NUMBER OF AGGRESSIVE ACTS
0
10
20
30
40
50
60
70
80
90
1
2
3
4
5
6
7
8
9
10
DAYS AFTER REGROUPING

Figure II.3. The mean hourly occurrence of aggressive acts (headbunts+bunts+threats) among bulls and steers for 10 days following regrouping: Age circa 15 months, July 1982 Data collected between 0900 h and 2100 h.

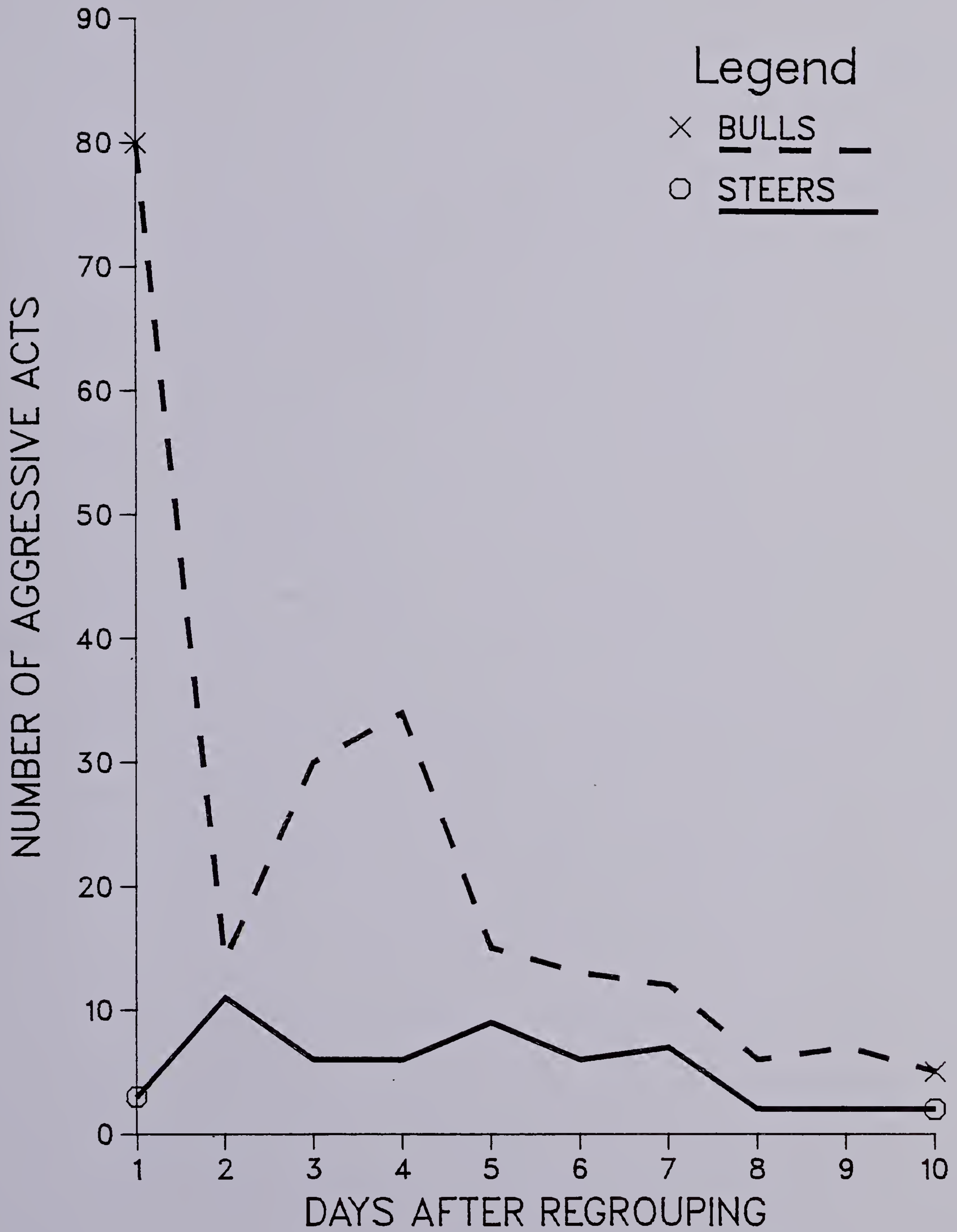
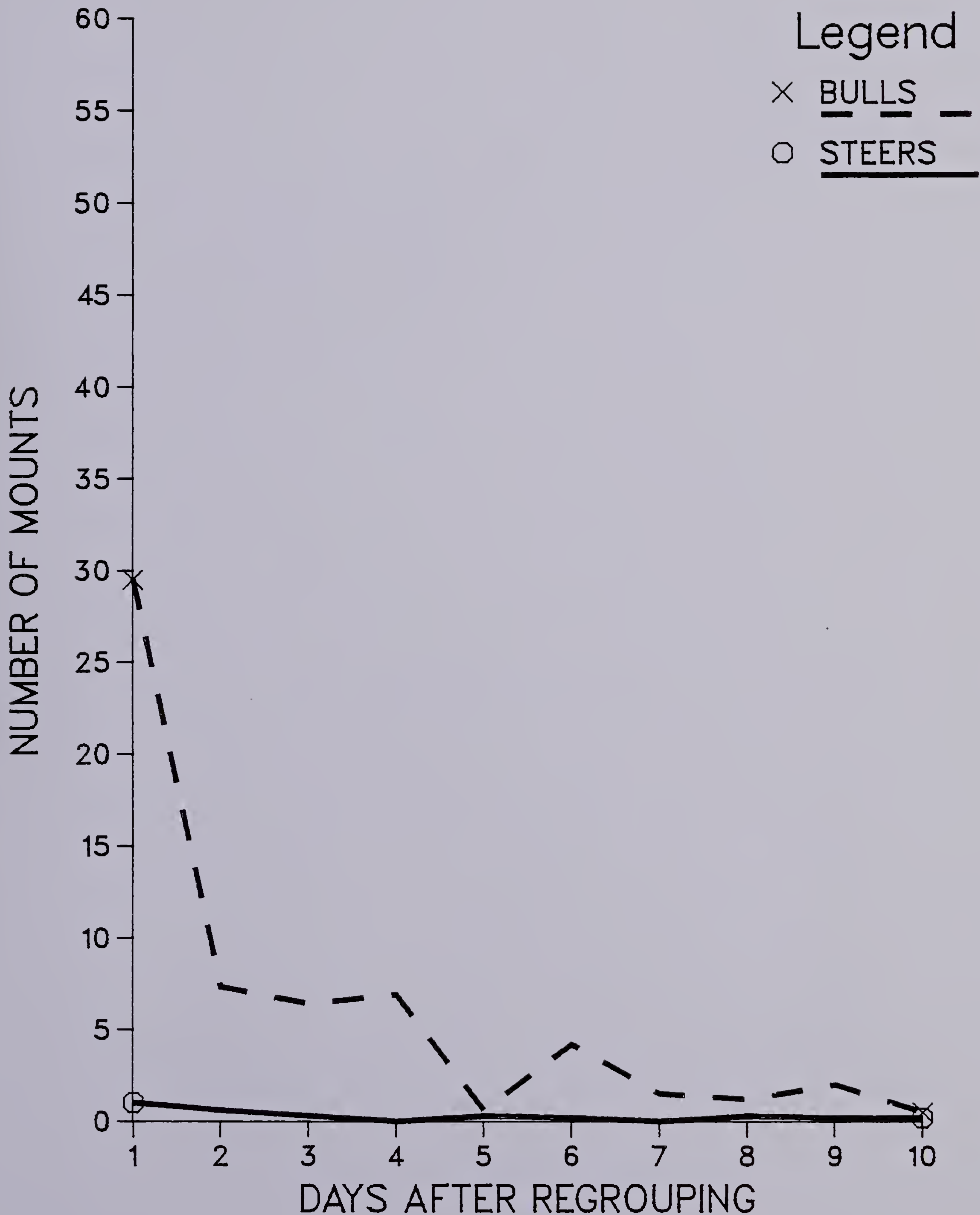

Legend
BULLS
STEERS
NUMBER OF AGGRESSIVE ACTS
DAYS AFTER REGROUPING
0
10
20
30
40
50
60
70
80
90
1
2
3
4
5
6
7
8
9
10

Figure II.4. The mean hourly occurrence of mounting among bulls and steers for 10 days following regrouping: Age circa 9 months, January 1982. Data collected between 0900 h and 2100 h.



Legend
BULLS
STEERS
NUMBER OF MOUNTS
0
5
10
15
20
25
30
35
40
45
50
55
60
1
2
3
4
5
6
7
8
9
10
DAYS AFTER REGROUPING

Figure II.5. The mean hourly occurrence of mounting among bulls and steers for 10 days following regrouping: Age circa 12 months, April 1982. Data collected between 0900 h and 2100 h.

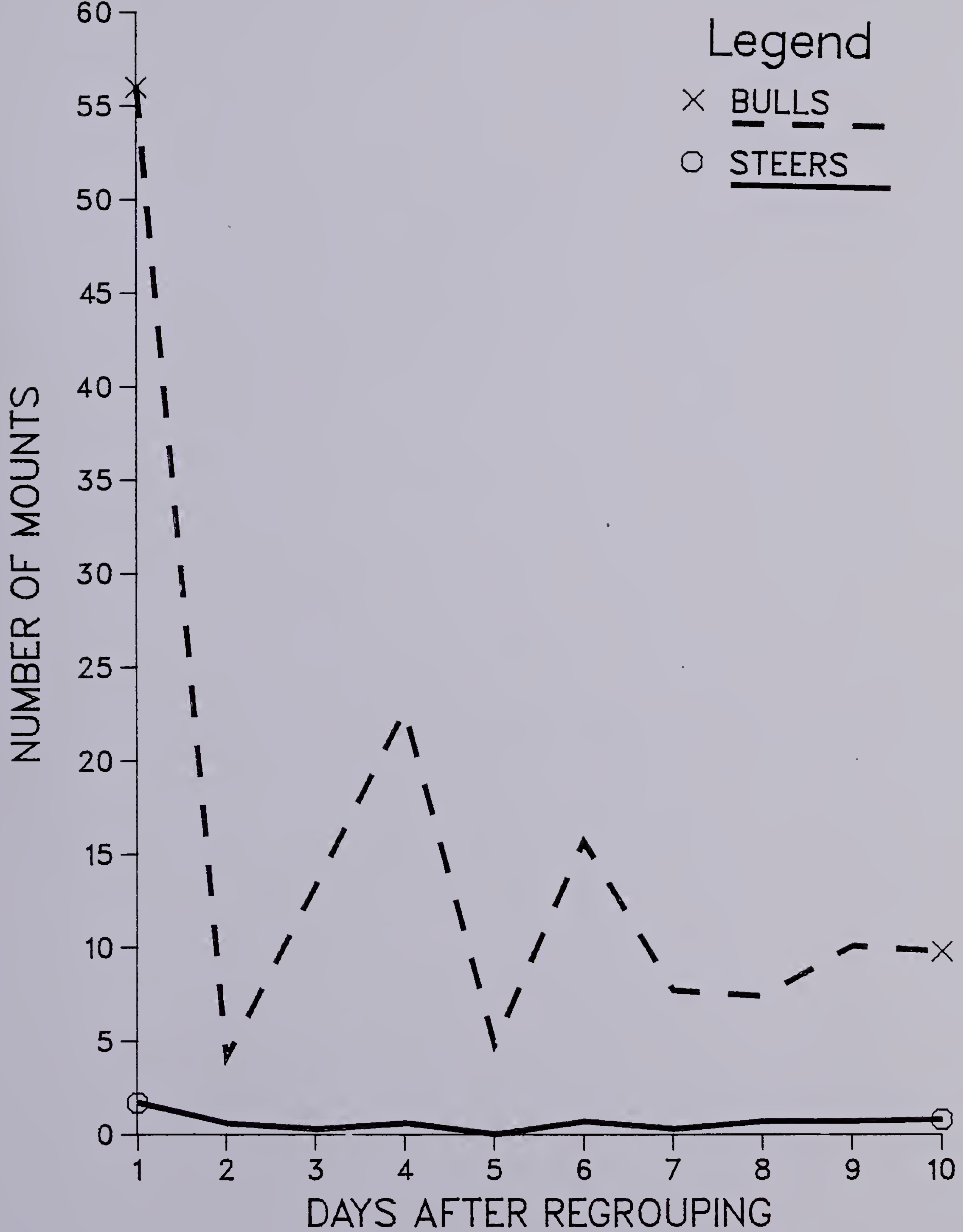
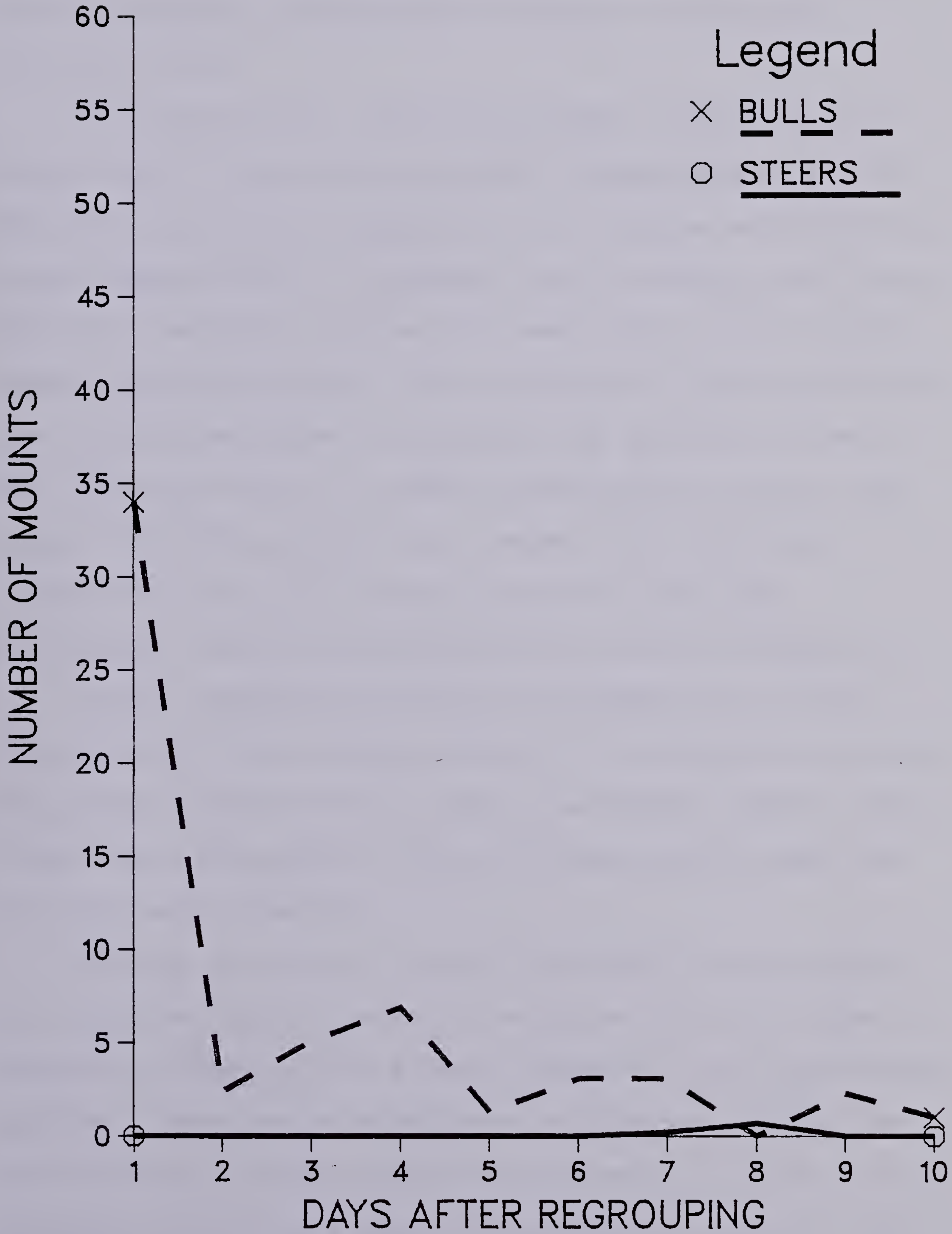

Legend
BULLS
STEERS
NUMBER OF MOUNTS
DAYS AFTER REGROUPING
60
55
50
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10

Figure II.6. The mean hourly occurrence of mounting among bulls and steers for 10 days following regrouping: Age circa 15 months, July 1982. Data collected between 0900 h and 2100 h.


Legend
BULLS
STEERS
NUMBER OF MOUNTS
DAYS AFTER REGROUPING
0
5
10
15
20
25
30
35
40
45
50
55
60
1
2
3
4
5
6
7
8
9
10

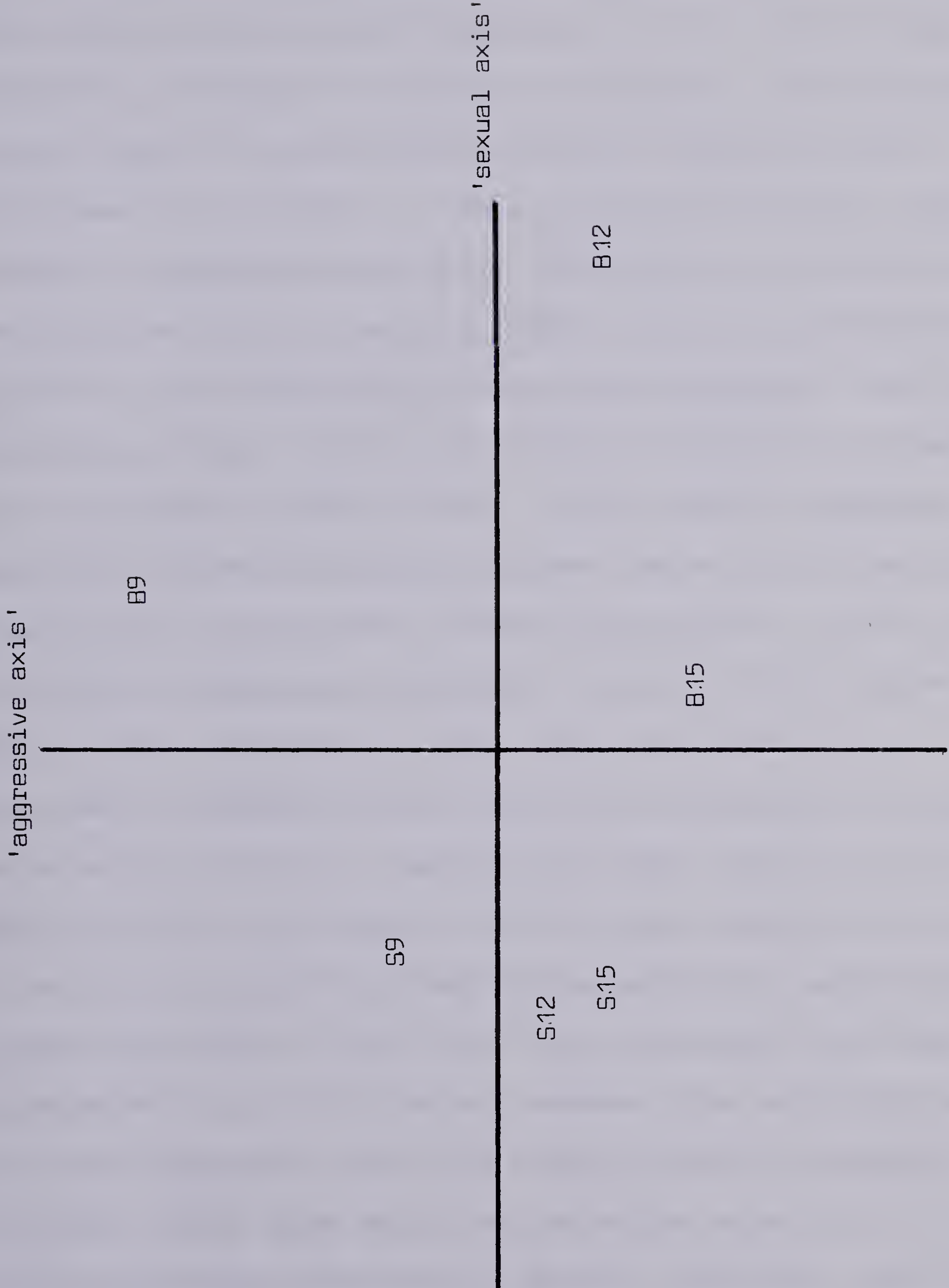
frequency of mounting than steers, even after 10 days ($p<0.01$). Mounting, as opposed to aggressive behaviour, was not significantly correlated with ambient temperature ($r=0.038$, $p>.5$).

In a discriminant function analysis (Figure II.7), a 'sexual axis' (the ordinate) and an 'aggressive axis' (the abscissa) are used to separate the two castes and three age groups respectively. I interpret this as showing that sexual behaviour (mounting, flehmen) is best able to discriminate between bulls and steers. All age groups of bulls performed more sex-related behaviour than all age groups of steers. The 'aggressive axis' is able to discriminate between age groups. Generally, there was a tendency for the older animals to fight for a shorter period of time. The discriminant function coefficients are given in Appendix 2.

Another category of activity recorded was cribbing. This behaviour occurred sporadically in both castes. Neither caste predominated since at age twelve months (April) steers cribbed more than bulls, and at fifteen months (July) the positions were reversed.

Finally, it has been argued (Wood 1977) that grooming is a positive form of social interaction and is an index of strength of bonds within a herd. Taking all three age groups together, there was no significant difference between the two sex-castes in the frequency of grooming. It may be that grooming would be more appropriately studied within a well established herd.

Figure II.7. Discriminant function analysis to separate age-sex groups. Plotted points represent bulls (B) and steers (S) at ages circa nine (9), twelve (12) and fifteen (15) months. The 'aggressive axis' reflects amount of time spent fighting. The 'sexual axis' reflects frequency of mounts and flehmen.



'sexual axis'
'aggressive axis'
B12
B9
B15
S9
S12
S15

This research concerned the effects of the removal of the testes on the social behaviour of male cattle. Past research, primarily on rodents and primates, has produced three lines of correlational evidence suggesting that androgens are related to levels of aggressiveness. First, levels of aggressive behaviour rise along with levels of testosterone during breeding season. Second, aggressiveness is often first exhibited at the time of puberty. And third, baseline androgen levels and levels of aggressive behaviour are correlated (Leshner 1975). In the case of agonistic behaviour, hormones probably affect behaviour by modifying those brain circuits that control aggression, but not those involved in submissive behaviour (Leshner 1975, Leshner and Moyer 1975). "Androgens affect only the intensity of aggressive responses and do not affect avoidance responses to agonistic stimuli" (Leshner and Moyer 1975). Much of the data related to aggression and androgens comes from studies in which strangers have been introduced in a testing arena. Leshner and Moyer (1975) found that castrated rats were less aggressive than entire males; however, the castrates were not more submissive, and they fought back if attacked. Bouissou (1983) gave daily testosterone injections to heifers from age three to six months. She found that the treated heifers fought more when introduced to strangers than did untreated controls, and she explains the results by proposing that androgens reduce fear.

It has been reported for bulls (Venediktova et al. 1977) and for steers (McPhee et al. 1964), that regrouping leads to an increase in aggressive and sex-related social interactions. From Figures II.1 to II.3 it can be seen that mixing led to more aggressive behaviour among bulls than among steers. The magnitude of the difference changed with age, although effects of age cannot be separated in this study, from those of body weight, body fatness, temperature, and daily photoperiod. However, the data reveal that steers performed 63% as many aggressive interactions as bulls at age nine months. The gap between the castes increased with age: and by twelve months, the figure dropped to 57%, and by fifteen months, steers performed only 32% the number of aggressive acts of bulls. This is a reflection of the overall decreased rate of aggressive behaviours among 15 month old steers. The rate of aggressive behaviour also dropped in bulls.

Subjective analysis of aggressive behaviour within each caste suggests that steers are less 'serious' in their agonistic interactions than bulls. Fights seemed less intense, and did not last as long. However, aggressive behaviour plays a role in the establishment of a dominance hierarchy, and it has been shown that steers as young as eight months form a rank order (Stricklin et al. 1982). Based on the number of agonistic interactions I observed, the rank order among steers is established with fewer overt signs of aggression than among bulls. Similarly, Stricklin

and Gonyou (1981) found less overtly competitive behaviour among steers at a single stall feeder than among bulls. They found that among the steers, high ranking animals were more readily replaced at the feedbunk by low ranking ones.

However, two important variables (in addition to time after regrouping) must be considered when discussing social behaviour: group size and stocking density. This study dealt with small pens, 55.8 m^2, holding eight animals: 7 m^2/animal. By contrast, McPhee et al. (1964) studied six steers at a stocking density of 12.4 m^2/animal, and Hinch et al. (1983) observed grazing steers and bulls in herds of 24 at a density of almost 3000 m^2/animal. That may account for the much lower rates of aggressive behaviour among the bulls and steers described for their cattle.

Hinde's (1969) argument that in nature, most aggression is proximity induced is supported by data on growing pigs. Kelley et al. (1980) found that a reduction in free space led to more frequent contacts and more aggressive behaviour. It has been reported (Hinch 1978, Hinch et al. 1983) that differences in the frequencies of social interactions among bulls and steers are not significant until 14 or 15 months of age. That conclusion may apply to bulls and steers kept at very low stocking densities where, as Fraser (1982) pointed out, avoidance serves to reduce agonistic contests between animals. In this study, sex-caste differences in agonistic and sexual behaviour were significant even at nine months. This is most likely due to the much higher stocking

density of feedlot cattle versus those on pasture, which served to magnify differences.

The second variable that must be taken into account, group size, has implications independent of stocking density. Aggressive behaviour is in part related to the establishment of a dominance hierarchy. In cattle, the final order is largely the result of the interactions of each pair of animals. Because the number of combinations of pairs increases with the number of animals, activity in a large newly formed group can be expected to normalize much more slowly than in a small group.

Group size is also important owing to the effect of social facilitation. Behaviours such as grazing or feeding are 'contagious' and will spread to other animals if begun by a few. This may also apply to mounting among cattle (Reinhart et al. 1978).

The differences that exist between bulls and steers are hormonal in origin. Steers cannot produce testicular male hormone. This has, for example, led to a different pattern of muscular development in steers and bulls. Steers never develop the complete muscle distribution pattern of the mature male. In this regard, steers are 'immature' bulls (Berg and Butterfield 1976). Differences in behavioural development between steers and bulls may be analogous to differences in muscular development. The sexual behaviour of the adult male is never developed by the castrate. To a less extreme degree, the aggressive behaviour of the adult male,

which has evolved in relation to dominance formation and access to resources, including mating partners (Lott 1981), is not developed in the castrate. Therefore, some of the differences in social behaviour may be explained by the steer being a behaviourally less mature animal. That is the same conclusion reached by workers in Australia who cited their observations that bulls showed reduction in play behaviour (running) and increase in social grooming at an earlier age than steers (Hinch et al. 1983).

The data on sexual behaviour make it clear that bulls were much more occupied with mounting each other than were steers. The high rate of mounting immediately after mixing also suggests that mounting may play a role in the investigation of unfamiliar animals. Therefore, mounting is perhaps the most difficult behaviour to interpret. Mounting of an estrus cow by a bull is, of course, regarded as typical sexual behaviour. The motivating drive is explained in terms of libido. But is the mounting observed in this study also a function of libido? Reinhart et al. (1978) observing 5 to 10 month old male and female African Boran cattle (Bos indicus), came to the conclusion that mounting was play behaviour, because it lacked "serious motivation" and because the roles were reversible. Yet Hinch et al. (1983) regarded homosexual mounting done by 10 month old Hereford bulls and steers as sexual behaviour.

Mounting may also be a manifestation of agonistic behaviour. Lott (1974) observed that dominant bison bulls

(<u>Bison bison</u>) often responded to the submission signals of other bulls with chin-rest movements and with soft panting. Both are considered mounting intention movements in bison. Geist (1971) described dominant Bighorn rams (<u>Ovis canadensis</u>) mounting younger males lower in the hierarchy. He explained this as a ritualized extension of the dominant male and submissive female roles of wild sheep during mating. A low ranking male may actually perform lordosis when mounted by a dominant ram. If, in cattle, mounting is at a high level immediately after regrouping but decreases thereafter, it suggests that mounting may have an agonistic as well as a sexual role. That was the case with the bulls in this study which over all ages had a mean incidence of 15.5 mounts/pen/hour during the first five days, but a lower rate of only 4.4 mounts/pen/hour for the second five days. Among bulls, it may be that mounting functions both as sexual behaviour and aggressive, dominance asserting, behaviour. For both bulls and steers, there was a significant correlation between mounting and aggressive behaviour ($r=.730$ and $r=.437$ respectively, $p<.001$). On the other hand, if steers are considered behaviourally less mature than bulls, mounting may have components of sexual, aggressive and play behaviour. From the current work it can be calculated that at ages 9 and 12 months, the sexual behaviour of steers as a percentage of the rate of that behaviour among bulls was 10% and 9% respectively. At age 15 months, that dropped to 3%. Perhaps what was originally play

behaviour among steers, declined as the castrates belatedly matured, but was not replaced by any behaviour associated with the presence of testosterone.

Finally, thyroid hormone and adrenal weight data (Appendix 3) showed no significant difference between bulls and steers. Adrenal gland weight reflects adrenal hypertrophy which is an approximate long-term indication of secretory activity (Leshner 1978). Prolonged and heightened adrenal secretory activity would suggest that the animals had been stressed during their stay in the feedlot. Thyroid hormones reflect general metabolic activity, and thyroxine levels may also increase at times of stress (Archer 1979). Altogether, the lack of significant differences between the castes in adrenal weights or thyroid hormone levels, makes it tempting to speculate that the bulls were no more stressed by their nine to ten months in the feedlot than the steers. Although the bulls' response to regrouping was more dramatic than that of the steers, social stability and presumably a less stressful existence quickly returned.

CONCLUSION

After mixing, entire males showed a greater increase in aggressive and sexual interactions than castrates. This was evident at ages nine, twelve and fifteen months. Furthermore, the difference between bulls and steers increased, with increasing age. These animals were studied in groups of eight, and aggressive and sexual behaviour

decreased to normal levels within ten days. Hinch, et al. (1983) reported that aggressive behaviour rose considerably in bulls from fourteen months to eighteen months of age. The animals in the current work were slaughtered at fifteen months, so fighting and threat of injury may become a problem if bulls are kept beyond that age. However, the findings reported here for small groups of bulls and steers may not hold for large commercial herds, where social stability may be unattainable due to the difficulty of individual recognition.

III. BEHAVIOUR OF BULLS AND STEERS IN LARGE COMMERCIAL GROUPS

INTRODUCTION

In Chapter II it was shown that regrouping unacquainted cattle led to a much greater escalation of agonistic and sexual behaviour among bulls than among steers. It was also found that the initially high levels of activity soon declined, and that by ten days post-mixing, there was no statistically significant difference ($p>0.10$) between the average frequency of agonistic behaviours (bunts, headbunts, threats) among steers and bulls. Mounting behaviour remained higher in bulls. But those data described groups of only eight animals each, housed in 56 m^2 pens. Commercial feeding of bulls is becoming increasingly popular in Canada and under commercial conditions, bulls are likely to be penned in much larger groups. Fifty to 400 is normal for steers. Such group sizes have important ramifications for the nature and stability of social interactions. Increase in group size involves increasing the number of inter-animal relationships. Since the frequency with which any two animals in a group meet each other is inversely proportional to group size, the stability of the dominance order is likely to be inversely related to group size (Curtis 1981). Lott (1974) found that to be the case in herds of bison (*Bison bison*).

Increases in group size may not only affect the social life in the pen, but also weight gain and other measures of productivity. Ewbank (1975) argues that growing pigs should not be kept in groups greater than 20 to 25, because that is about the upper limit for the number of pigs that can establish a stable social hierarchy. Within narrow limits, changes in group size may lead to no changes in either behaviour or productivity. Sather (1982) found that with stocking density being kept constant, there was no difference in average daily gain or feed conversion efficiency between boars kept in groups of 2 or groups of 4. But if numbers are increased several fold, changes could arise. The purpose of this study was to document the frequencies of sexual, agonistic and other activities among steers and bulls in commercial-size groups.

MATERIALS AND METHODS

Cattleland Feedyards near Strathmore, Alberta feeds both bulls and steers. With the co-operation of the managers at Cattleland, an observation tower was built above a north-south fenceline separating a pen of bulls and a pen of steers. The observation platform was 4.2 m above the ground. Each pen was circa 60 m square and a feedbunk occupied the entire south end of each pen. The population of each pen varied between 210 and 220 animals during the course of the study. The cattle were all of mixed breeding, and were approximately 8 to 11 months old during the study, at the

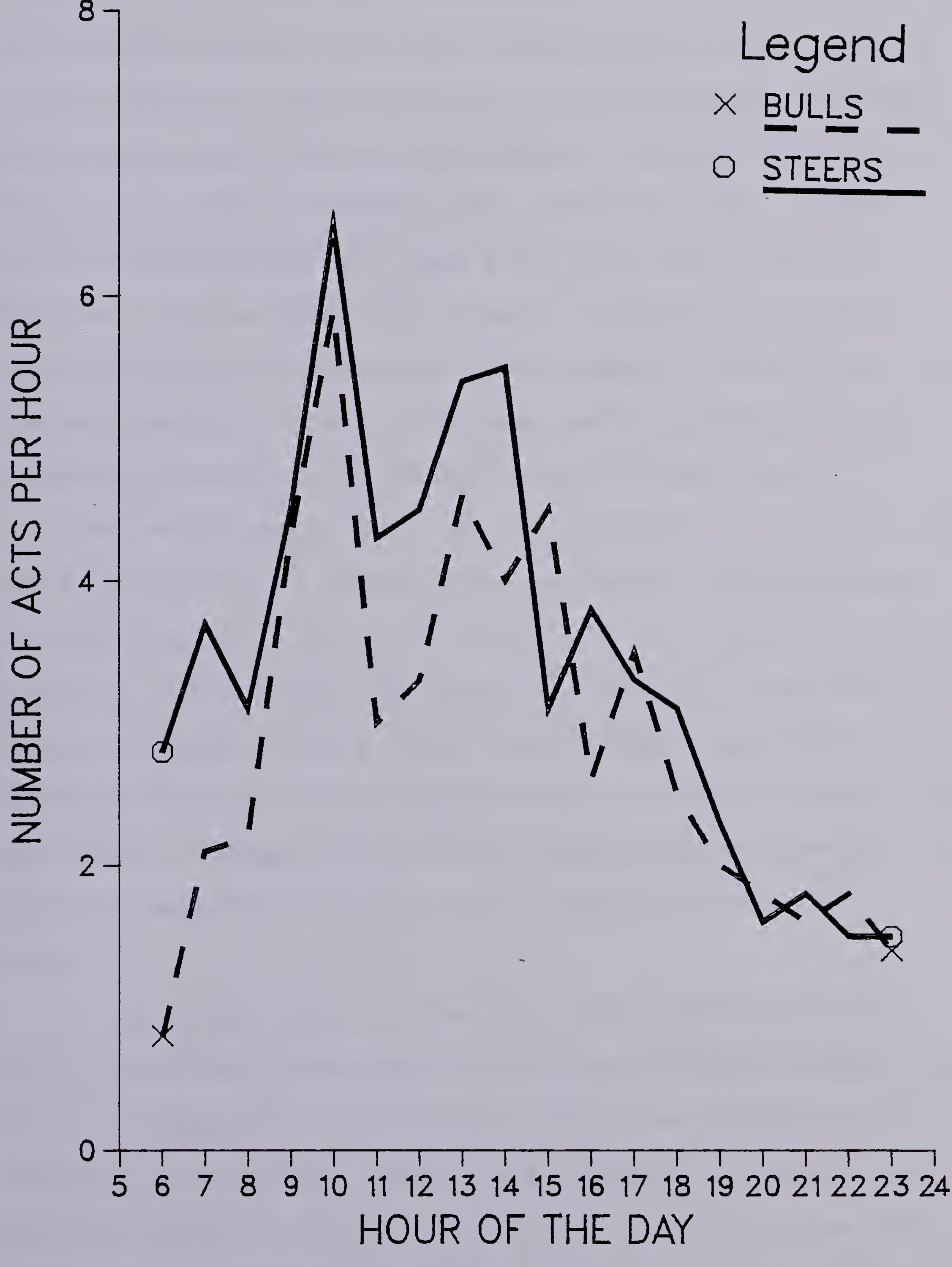
start of which the animals had been together for two months.

Between January and April 1983, eight observation sessions were made at Cattleland. For the first three sessions, observations were made for 24 h continuously. For the last five sessions, observations were made only from 0600 h to 2300 h. All-night observations were dropped because very little activity occurred. During the observation periods, the observer alternated every 30 min between watching the bulls and watching the steers. At the start of each 30 min observation period, a scan was made of the number of animals at the feedbunk, and an estimate was made of the percentage of animals lying down. During the 30 min, all occurrences of the following behaviours were recorded: mounting, bunting, gambolling (running about the pen with no obvious aggressive intent, and no body contact made), and finally cribbing (chewing or rubbing on the fence). The resultant damage to property is considered by some to be a possibly major drawback to keeping bulls. Ambient temperature, barometric pressure and relative humidity were recorded at 30 min intervals.

RESULTS AND DISCUSSION

Figure III.1 shows how often and at what times of day cribbing was seen in each caste. Although the emphasis of this chapter has been on social behaviour of bulls and steers, husbandrymen are also interested in other aspects of bull behaviour. During conversations with ranchers and

Figure III.1. The mean hourly occurrence of 'cribbing' (Chewing or rubbing on fencing) among bulls and steers in feedlot groups of circa 200. Data collected from 0600 h to 2300 h, January to April 1983.


Legend
BULLS
STEERS
NUMBER OF ACTS PER HOUR
0
2
4
6
8
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR OF THE DAY

feedlot operators, the concern is often expressed that bulls in large groups will damage fencing and other property because of their more violent aggressive behaviour. Surprisingly, steers were seen slightly more often engaging in this behaviour than were bulls. In this study, no damage estimate was made. However, during the course of the winter, neither pen sustained damage that required repair. Hinch (1978) studying bulls and steers at much lower stocking densities (0.9 head/hectare) found no differences between bulls and steers in amount of fence rubbing. But he did find a marked seasonal effect, with most rubbing coming in the spring when animals were shedding their winter coat.

The feeding pattern for the two groups was similar, with a peak early to mid-morning, and again late afternoon to early evening (Figures III.2 and III.3). Gonyou and Stricklin (1981) found that beef cattle fed at individual feeders had peak feeding times around 0900 h and 1900 h. The hourly pattern of resting (lying down) of the two castes was also similar. However fewer bulls rested during mid-day, and the bulls were active later into the evening than the steers.

On the other hand, in what are here considered to be social behaviours, important differences emerged between the bulls and castrates. Figure III.4 shows the average hourly frequency of mounting, bunting and 'gambolling' among the bulls and steers. Figures III.5, III.6 and III.7 show the distribution patterns of mounting, bunting and 'gambolling'

Figure III.2. The number of bulls and steers at the feedtrough at the beginning of half-hour observation periods from 0600 h to 2300 h, January to April 1983.

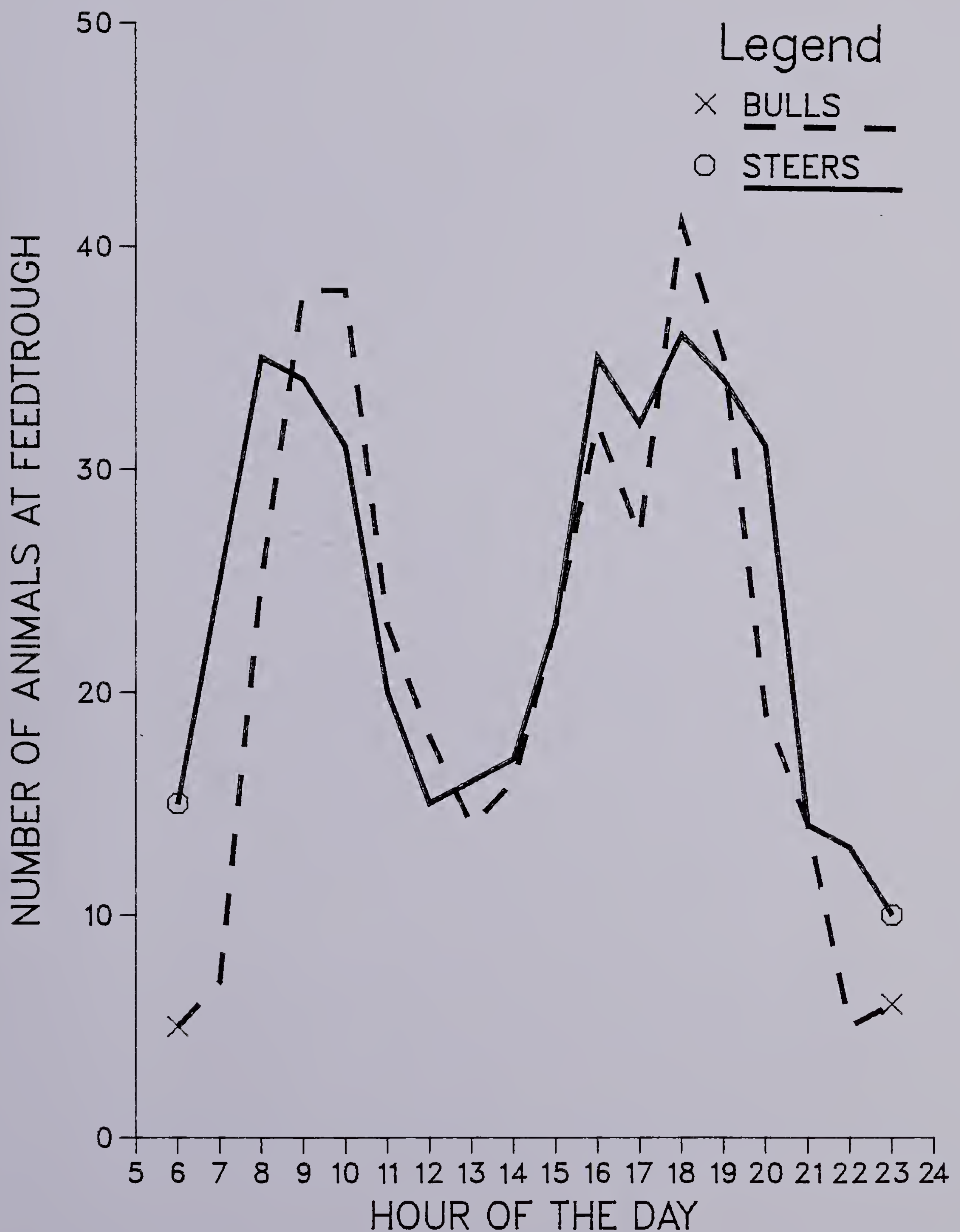
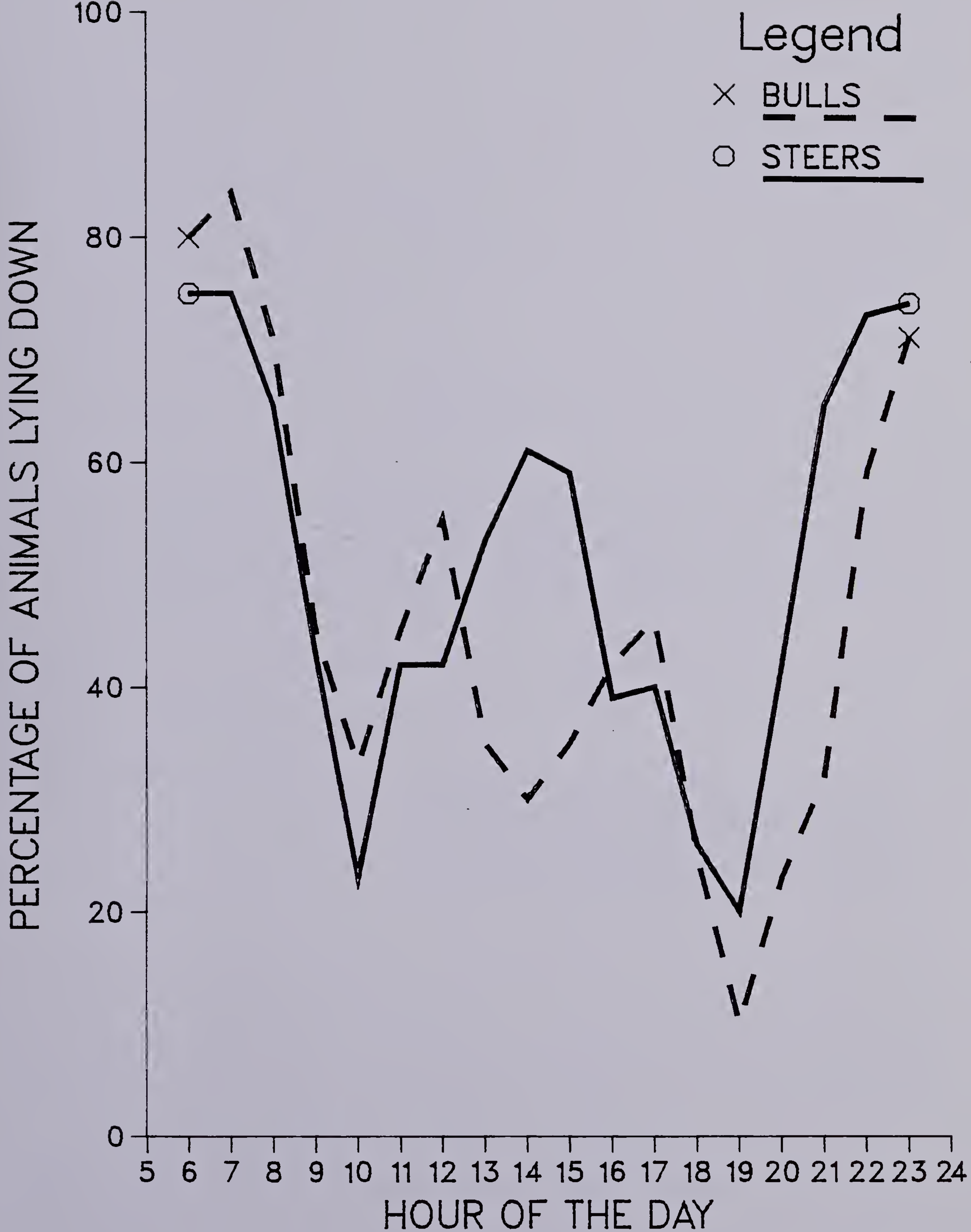
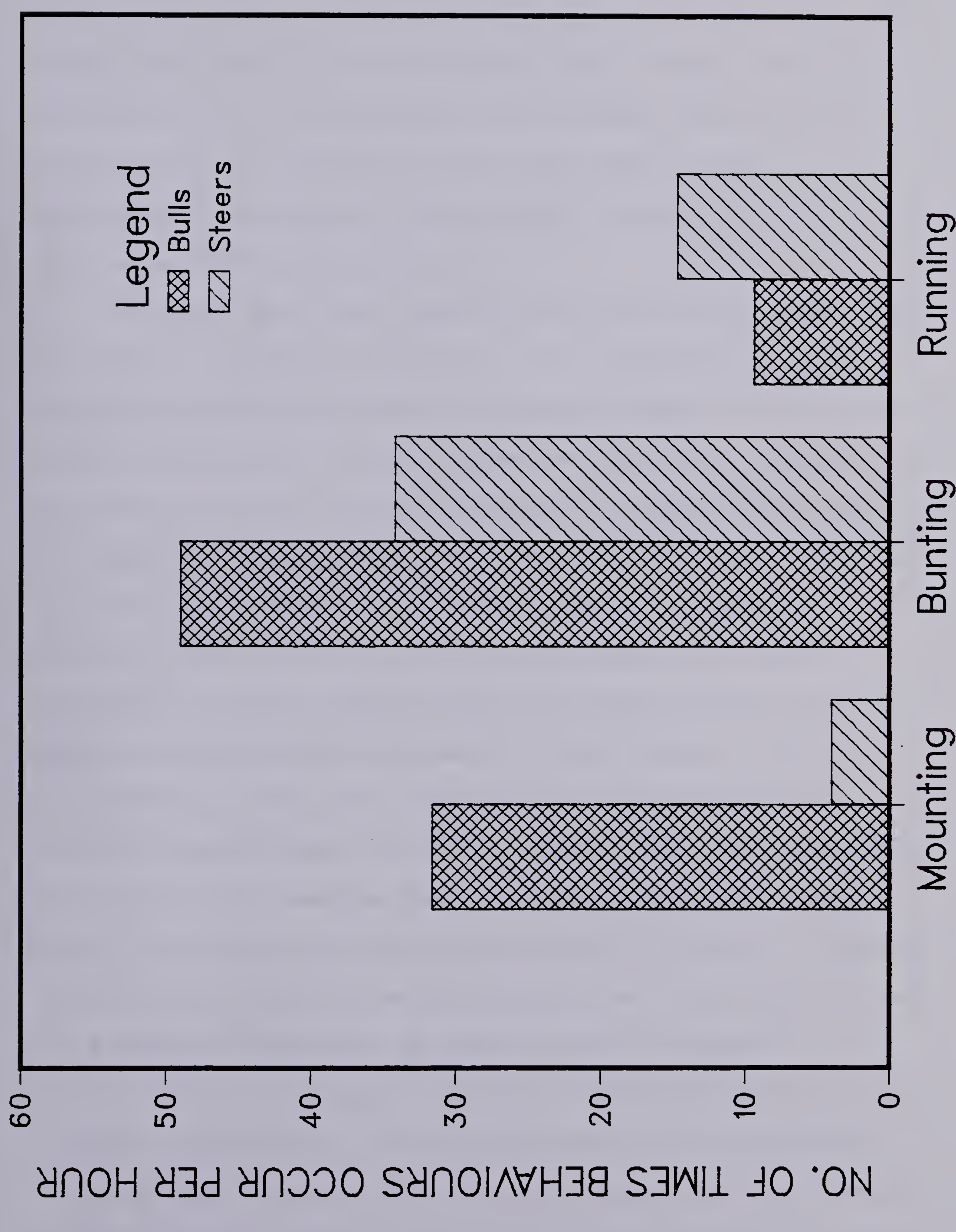

Legend
BULLS
STEERS
NUMBER OF ANIMALS AT FEEDTROUGH
0
10
20
30
40
50
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR OF THE DAY

Figure III.3. The estimated percentage of bulls and steers lying down at the beginning of half-hour observation periods from 0600 h to 2300 h, January to April 1983.



Legend
BULLS
STEERS
PERCENTAGE OF ANIMALS LYING DOWN
100
80
60
40
20
0
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR OF THE DAY

Figure III.4.The mean hourly occurrence of mounting, bunting and 'running' (gambolling) among bulls and steers in groups of circa 200. Data collected from 0600 h to 2300 h, January to April 1983.



Legend
Bulls
Steers
Mounting
Bunting
Running
0
10
20
30
40
50
60
NO. OF TIMES BEHAVIOURS OCCUR PER HOUR

over the 17 h observation period. It is evident that the bulls did much more mounting and somewhat more bunting; but steers were more often seen gambolling. Overall there is confirmation of the hypothesis that steers and bulls in large groups are different from each other in the distribution of activity among these categories (chi-square=944, df=3, $p<0.01$).

The most prominent behavioural difference between the two castes was sexual behaviour. As in Chapter II, which described bulls and steers in groups of eight, bulls in this study directed more sexual behaviour (mounting) toward their pen-mates than did steers. Mounting was comparatively rare and sporadic among steers, with only a small peak occurring in the early evening. On the other hand, the bulls in this group of over 200 exhibited mounting behaviour almost throughout the day. Major peaks took place at mid-morning, early afternoon and during most of the evening. Not so noticeable in the small group was the extent to which mounting among bulls occurred in bouts. That was especially true during the evening when periods of relatively little sexual behaviour would be interspersed by periods of intense mounting activity that would spread from a few bulls to many in a matter of minutes. At these times the social facilitative or contagious nature of mounting behaviour was evident. Furthermore the behaviour was often directed by 10-20 animals toward one or two, and would last for five to fifteen minutes. During the course of the study, four bulls

Figure III.5. The mean rate of mounting among bulls and steers in groups of circa 200. Data collected from 0600 h to 2300 h, January to April 1983.

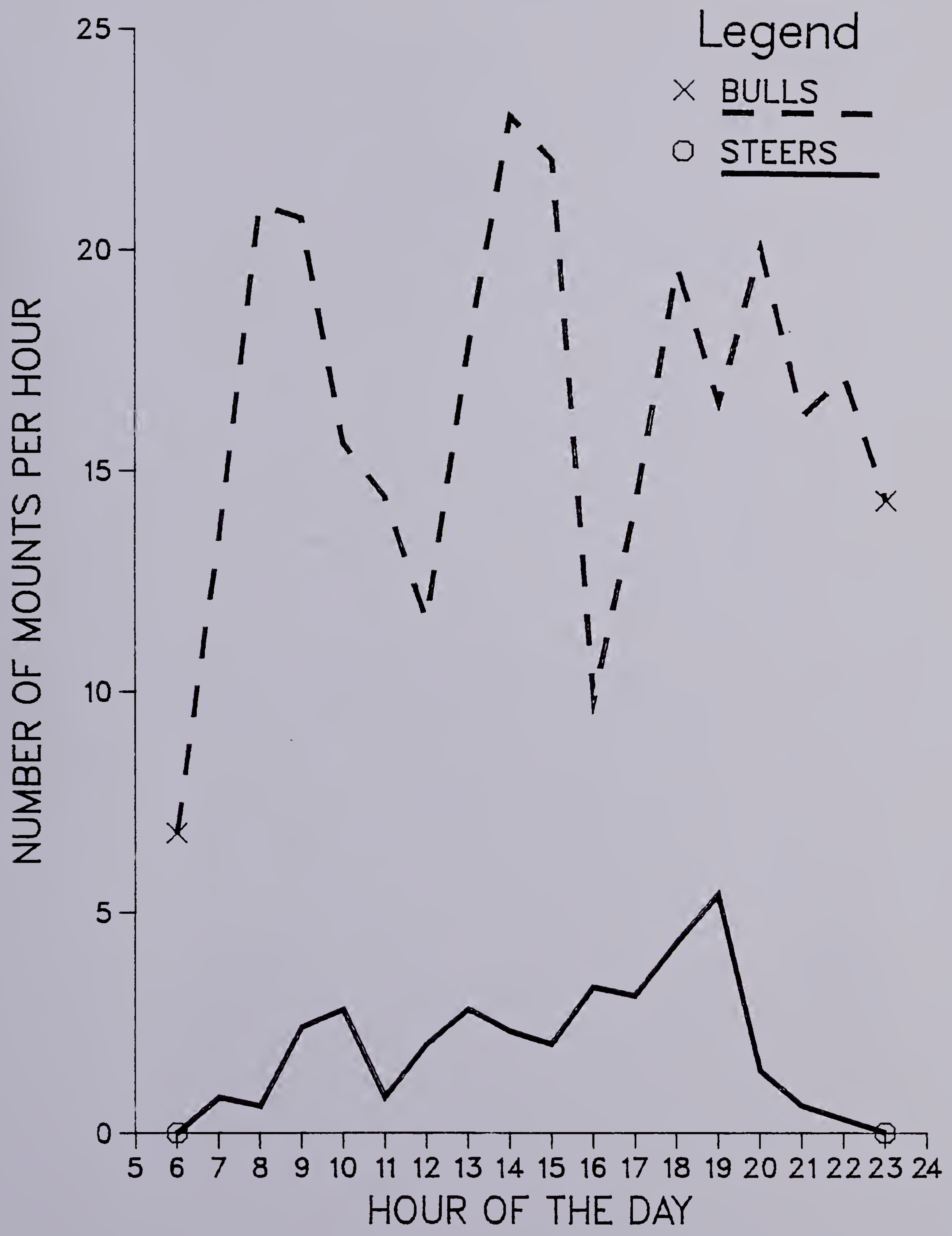

Legend
BULLS
STEERS
NUMBER OF MOUNTS PER HOUR
25
20
15
10
5
0
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR OF THE DAY

Figure III.6. The mean rate of bunting among bulls and steers in groups of circa 200. Data collected from 0600 h to 2300 h, January to April 1983.

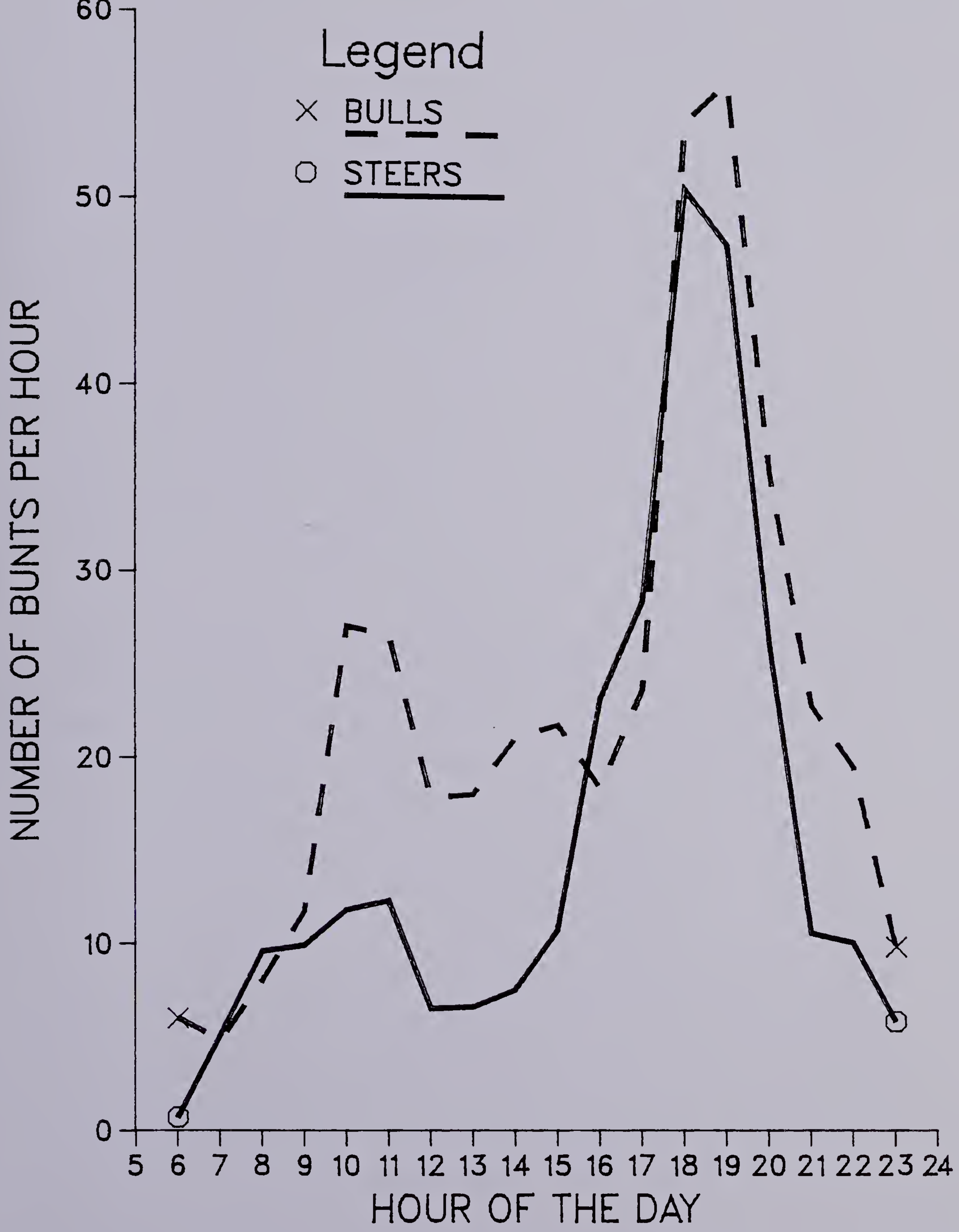
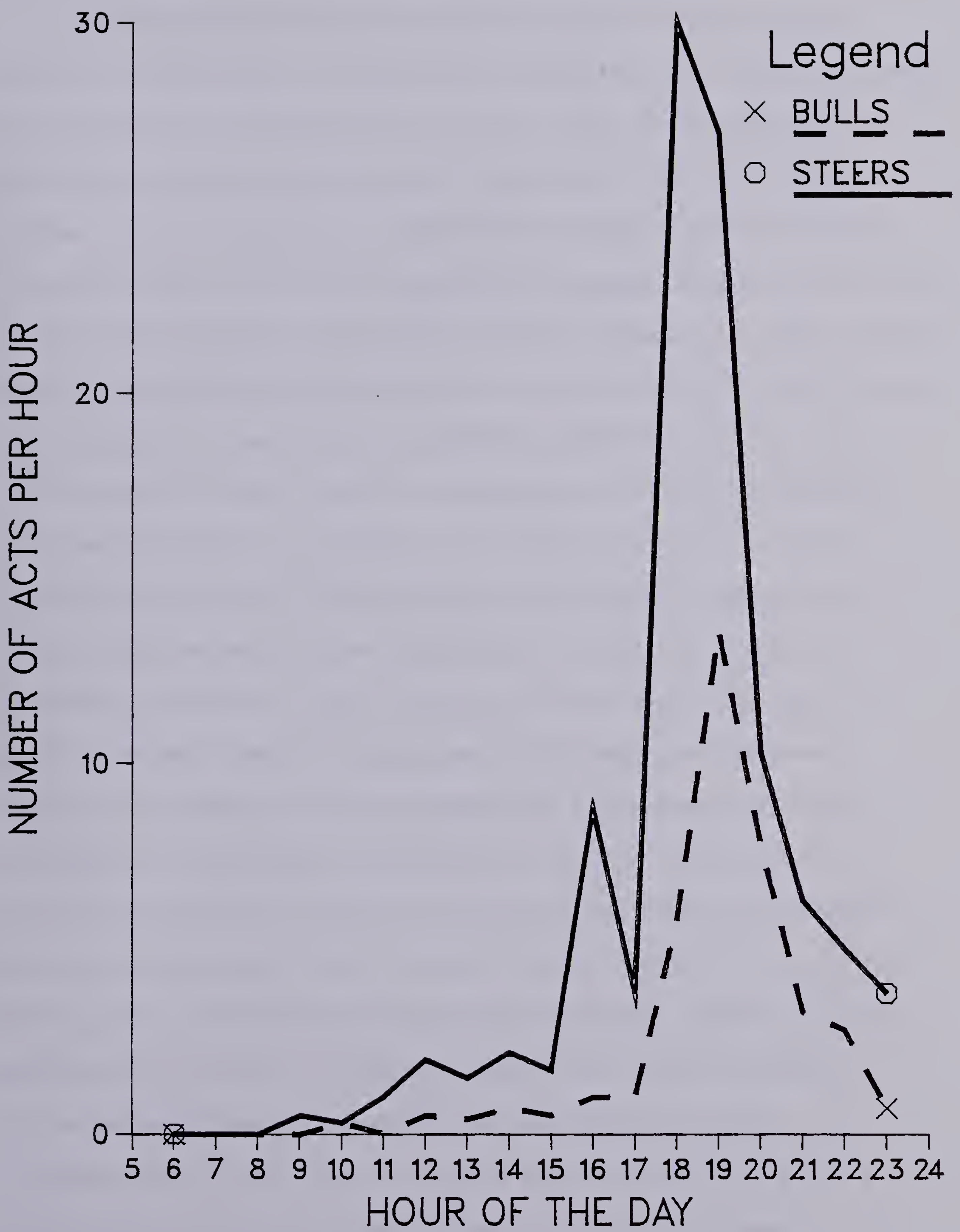

Legend
BULLS
STEERS
NUMBER OF BUNTS PER HOUR
0
10
20
30
40
50
60
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR OF THE DAY

Figure III.7. The mean rate of gambolling among bulls and steers in groups of circa 200. Data collected from 0600 h to 2300 h, January to April 1983.


Legend
BULLS
STEERS
NUMBER OF ACTS PER HOUR
30
20
10
0
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOUR OF THE DAY

were taken out of the pen because of poor condition thought to be brought on by this type of victimization.

Both bulls and steers showed a peak in aggressive behaviour (bunting) in the early evening. But bulls differed from steers in displaying a higher rate of the behaviour during late morning and early afternoon. The generally higher rate of aggressive behaviour among the bulls is a characteristic of these commercial groups that was not found in the data on the small experimental groups of eight. There are at least two plausible explanations for this. The first is related to dominance hierarchy formation. Either the cattle had not had time to establish a rank relationship with each other, or cattle are simply not able to form relationships with so many other individuals. Bulls may respond differently than castrates to such a socially unstable situation. That would coincide with the data on small groups, wherein bulls performed more sexual and aggressive behaviour than steers after regrouping with strangers. The second explanation is that agonistic interactions have a social facilitative effect as feeding behaviour has been shown to have (e.g. Warnick et al. 1977). Therefore, if the behaviour is contagious, there will be a mushrooming effect, tending to draw in other animals. If bulls have a lower threshold for engaging in such interactions, they would be more easily drawn in by the social facilitative effect. These are both arguments for keeping bull pens relatively small.

Also not predicted by observations made at The University of Alberta Ranch was the frequency with which steers, and to a lesser extent bulls, were seen gambolling about in their pens. This is behaviour which looks like the playing of calves. It may be, as claimed in Chapter II, that castrates never develop the complete adult behaviour pattern of mature males. Instead, the activities of the steers seem more like a persistence of play behaviour. And, as indicated, play is a behaviour that has been found to end at an earlier age among bulls than among steers, on pasture (Hinch et al. 1983). Play may be physically exhausting but perhaps not as emotionally straining as 'serious' fighting. According to Dantzer and Mormede (1983), emotional response may be the key to understanding physiological responses to all so-called stressors. That is, stressors (e.g. vigorous exercise) do not produce the typical 'stress response' pituitary-adrenal activity unless accompanied by some emotional trauma (fear, anxiety). This proposition has been supported by evidence showing that plasma corticosteroid levels do not become elevated if animal subjects are exposed to heat or cold slowly or if emotional arousal is carefully avoided during fasting or exercise (Mason 1971, Alvarez and Johnson 1973, Dantzer and Mormede 1983).

In a recent study of birds (Lagopus lagopus lagopus) those individuals that eventually became subordinate exhibited a greater reaction, measured as increase in body temperature and plasma corticosterone, than did those birds

that became dominant (Myhre et al 1981). The study also showed that the differences between dominant and subordinate individuals disappeared in a well-established hierarchy where rankings were seldom challenged. That led those researchers to suggest that energy conservation for both dominant and subordinate may be one function of a dominance hierarchy (Ursin and Myhre 1983). Making an extrapolation to cattle, it could be argued that large feedlot groups (those so large that bulls do not interact often enough to develop a stable relationship, or in which individuals simply cannot recognize all group members) result in an added energy drain to subordinate animals. The implication is that even production parameters such as rate of weight gain may be prejudiced in these circumstances, and some of the natural advantage of bulls over castrates thereby diminished.

In observing feedlot cattle behaviour, I have concentrated on their responses to the social environment. But cattle modify their behaviour according to changes in their total environment (physical and social). During my observations it was clear that weather had a profound effect on general level of activity. But in this connection, there may be many important variables, and their interaction with behaviour and motivation are complex. At a crude level, some relationships were seen. Both agonistic and sexual behaviour were positively correlated with ambient temperature ($r=0.135$, $p=0.024$ and $r=0.106$, $p=0.061$ respectively; temperature range: -12°C to 17°C). But some inverted-u curve

relationship may be expected, with general activity being reduced at much higher ambient temperatures. Barometric pressure and relative humidity were also recorded, but no significant correlations with activity were found. This study has not supplied sufficient data on behavioural responses to weather changes to make any predictions. Those relationships remain to be clarified. In the meantime, I assume that weather changes affect the behaviour of bulls and steers in the same direction. However the magnitude of the responses may differ.

IV. COMPARATIVE RESPONSES OF BULLS AND STEERS TO TRANSPORT

INTRODUCTION

A body of information now demonstrates advantages to raising bulls versus raising steers for beef (e.g. Field 1971, Jones et al. 1981). But feeding and marketing bulls for beef may also pose some management problems not encountered with steers. As already discussed, the dark-cutting of beef carcasses is a condition that is prevalent among bulls subjected to pre-slaughter stressors, and can mean economic losses to producers. One such stressor is the fighting that occurs before slaughter among animals unfamiliar with each other (McVeigh et al. 1979). It has been shown that regrouping bulls 24 h before slaughter can result in 73% of carcasses turning dark (Price and Tennessen 1981). Steers have been found to be less susceptible to dark-cutting (Chapter I). That is in accord with what have been shown to be differences between bulls and steers in their behavioural response to regrouping (Chapter II). Mixing led to a much greater escalation in aggressive and sexual behaviour among bulls than among steers. In general, bulls and steers differed markedly in how they responded to change in their social environment.

Another possible pre-slaughter stressor is the handling and transportation that takes place when cattle are moved from the feedlot to the abattoir. Addressing the topic of transportation and animal welfare, Taylor (1978) wrote that:

"Apart from the stressful situation produced by the mere change of its environment, various physical problems are posed, for example hunger and thirst, fatigue, too high or too low a temperature, crowding and unusual or excessive noise will all act as possible stressors."

And Grandin too (1978), points out that transport may be stressful to livestock because they may be exposed to thermal stress, noxious exhaust fumes and frightening noises. In this connection, it has been found that the frequency of dark-cutting beef from bulls increases with the time elapsed between departure from the farm and arrival at the abattoir (Monin and Royant 1980).

Is there a difference in how young bulls and steers respond behaviourally or physiologically to the experience of being loaded onto a truck and driven along the highway? If so, it would have a bearing on the economic feasibility of the husbandry of young bulls. The purpose of this study was to expose both bulls and steers to transport by truck, and to monitor that response.

MATERIALS AND METHODS

In this experiment, seven lots of six bulls and seven lots of six steers, cross-bred yearlings born and raised at The University of Alberta Ranch, were transported by truck for either 10 min or for 2 h. The longer period was intended to mimic the time needed to transport cattle from The

University of Alberta Ranch at Kinsella, Alberta to an abattoir in Edmonton. The shorter period was included to evaluate the effect of simply loading and unloading. Bulls and steers were transported separately. All lots were made up of pen mates. All pens had been together long enough for dominance hierarchies to be well established. The animals had not been transported before. The truck held six animals at a density of roughly 1.5 m^2 per head. The bed of the truck was built of wood. Straw was thrown on the bed. The trucking itself was done on a good paved road, except for a one-half km stretch of road between the University Ranch and the main highway. Speed was maintained at roughly 75 to 80 km/h. The 10 min transport routine was done entirely on gravel road adjacent to the University Ranch. The experiment was carried out over a period of 5 weeks. Ambient temperature during the experiment ranged from 17 to 28°C.

The following measurements were taken before and after transport: body weight, rectal temperature, respiratory rate (based on movements of the animal's flank while breathing), and a chute score 1 (docile) to 6 (wild) (Heisler 1979) (Table IV.1). A blood sample was collected in a vacutainer, via the caudal vein rather than the jugular, in the hope of minimizing fright to the animal. The samples were assayed for serum cortisol by means of a solid phase ^{125}I radioimmunoassay kit (Diagnostic Products Corporation, Los Angeles, California). In addition, one animal chosen from each transport group of six was fitted with a VHF radio

Table IV.1. Chute score based on behaviour while restrained in a headgate. (Heisler 1979, adapted from Tulloh 1961).

Category	Description	Score
Docile	Quiet, unperturbed	1
Slightly restless	Generally docile, frequent movement, may be stubborn	2
Restless	Continuous movement, slight struggling	3
Nervous	Restless, quivers and/or defecates	4
Wild	Restless, struggles violently, may bellow and froth at mouth	5
Aggressive	Wild, may attack by kicking or attempting to bunt	6

telemetry system (Biotelemetry Systems Inc., Rush, New York) which allowed heart rate to be monitored during the trucking. The system was installed one-half hour before transport. The transmitter was mounted on a harness which was attached to the animal. See Plates IV.1 and IV.2. Two self-adhesive Stress Test Electrodes (3M Corporation, Minneapolis, Minnesota) fastened to the skin, one underneath the harness between the scapulae, and the other circa 60 cm behind the harness.

During handling, every effort was made to minimize disturbance to the animals. The cattle were never run, but rather allowed to walk out of their pen and along the runway to the chute system. Although the cattle had to be coerced onto the truck (pushed from behind and slapped on their backs), the unloading was done by simply opening the truck door and letting the animals exit at their own speed, which they did readily. After unloading, the cattle were moved in as calm a manner as possible to the chute system where measurements were taken. It should be noted that the cattle were not tamed to human contact, and their usual response was to withdraw whenever people approached. Therefore, handling and blood sampling were probably stressful experiences in themselves.

Data were analyzed by least squares analysis of variance.

Plates IV.1. and IV.2. Bull wearing harness with heart rate transmitter during transport study.

RESULTS

Table IV.2 shows the average values of variables recorded for bulls and castrates before the animals were trucked. Bulls were significantly heavier than steers, and had considerably lower serum cortisol levels. Table IV.3 shows the average change in the measurements with trucking. No consistent differences appear. Weight loss was the same for both castes. Similarly, changes in serum cortisol levels do not point to any differences between bulls and steers, although the basal levels of cortisol seem to be higher in castrates (Table IV.2). The two-hour transport produced no differences between the castes in respiratory rate or chute score. But the short 10 min process led to a much greater increase in respiratory rate among steers than bulls. Differences in chute score also only appear after the short duration transport. Heart rate data (Figure IV.1) showed that a peak was reached as the animals were loaded onto the truck. Thereafter, heart rate in both bulls and steers decreased slightly during the two hours of transport.

DISCUSSION

Although bull/steer differences in sexual and aggressive behaviour were minimal below 14 months of age in pasture grazing situations (Hinch et al. 1983), those differences can be accentuated by social regrouping (Chapter II), or by increasing the group size or stocking density (Chapter III). On the other hand, this study found few

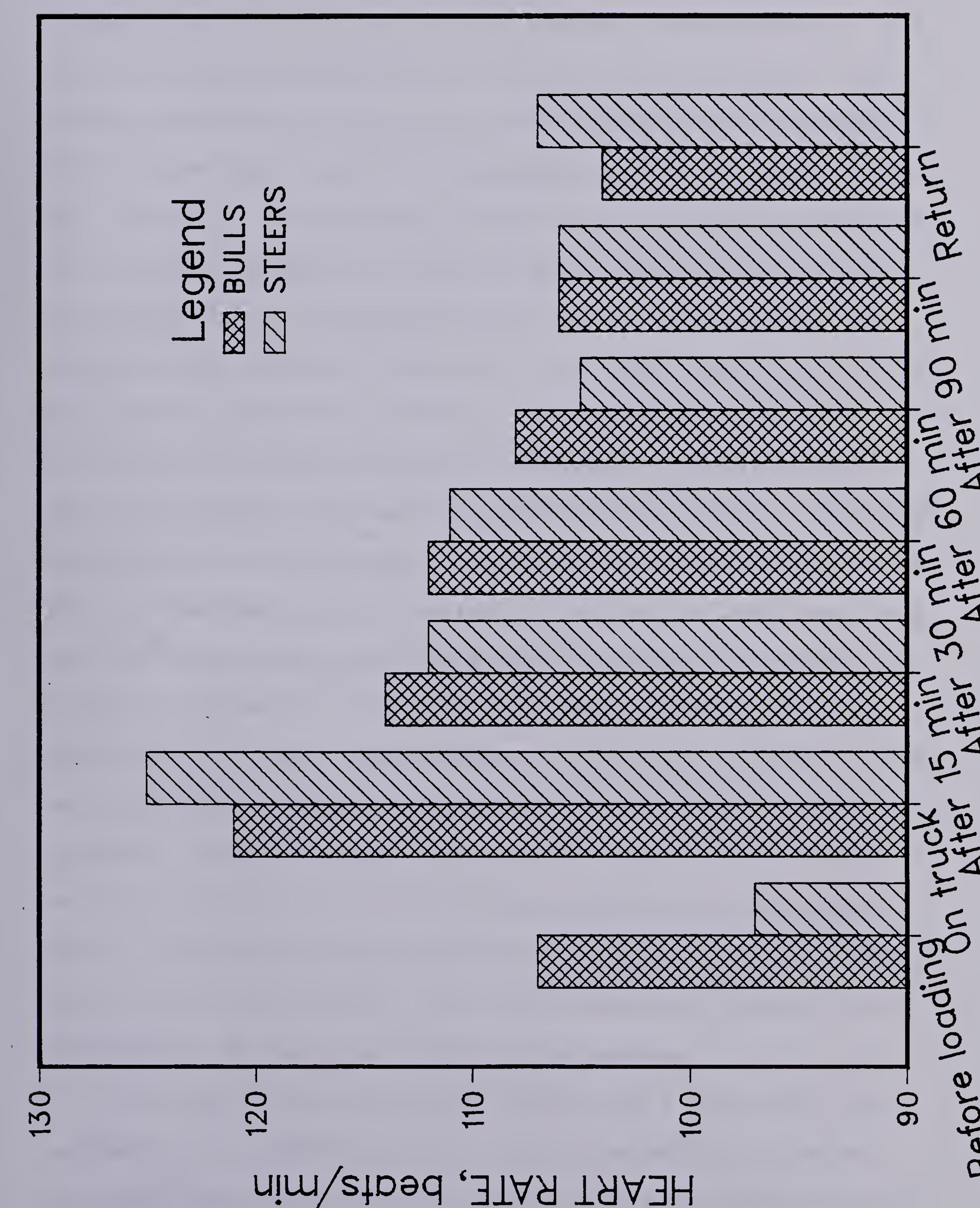
Table IV.2. Values of physiological and behavioural measures before transport, (mean ± SE).

	Body Weight (kg)	Respiratory rate (breaths/min)	Rectal temp. (°C)	Serum cortisol (ug/dl)	Chute score (1-6 scale)
Bulls	513 ± 8.5	66.6 ± 2.0	39.2 ± 0.1	1.9 ± 0.2	2.5 ± 0.2
Steers	473 ± 8.6	62.7 ± 2.0	39.3 ± 0.1	4.8 ± 0.4	2.3 ± 0.2
	P=0.001	P=0.173	P=0.510	P<0.001	P=0.637

Table IV.3. Changes in physiological and behavioural responses of bulls and steers after 2 hours or 10 min of truck transport (Means ± SE)

	% Weight loss	Increase in respiratory rate (breaths/min)	Increase in rectal temp. (°C)	Increase in serum cortisol (ug/dl)	Increase in chute score
2 h					
Bulls	2.2 ± 0.1	4.0 ± 2.8	0.0 ± 0.11	0.6 ± 0.6	0.1 ± 0.2
Steers	2.2 ± 0.1	3.7 ± 2.5	0.5 ± 0.10	-0.1 ± 0.5	0.2 ± 0.2
10 min					
Bulls	1.6 ± 0.2	0.3 ± 3.0	0.4 ± 0.10	0.0 ± 0.5	-0.4 ± 0.2
Steers	1.6 ± 0.1	8.1 ± 2.9	0.4 ± 0.11	1.1 ± 0.6	0.3 ± 0.3
Effect of sex	P=0.903	P=0.185	P=0.004	P=0.663	P=0.085
Effect of time	P<0.001	P=0.904	P=0.311	P=0.580	P=0.472
Sex x time	P=0.999	P=0.158	P=0.018	P=0.106	P=0.208

Figure IV.1. The heart rate of bulls and steers while transported by truck on paved highway. Values are means of three bulls and three steers.


HEART RATE, beats/min
130
120
110
100
90
Legend
BULLS
STEERS
Before loading
On truck
After 15 min
After 30 min
After 60 min
After 90 min
Return

differences in how 15-17 month old bulls and steers respond to transport by truck. The results suggest that spending two hours on a truck did not affect either group adversely, and did not produce physiological changes very different from those produced by little more than loading and unloading. But it must be noted that animals were not regrouped prior to transport. Considerable differences in physiological and behavioural parameters of regrouped animals would have been predicted due to the stress inherent in establishing new social relationships. Otherwise, the responses of the cattle may be in large part a function of the discomfort the animals felt during transport. Discomfort (physical and social) probably increases as crowding increases (individual distances are unavoidably trespassed), and probably also as footing becomes worse. Footing is related to the floor type of the truck, and also to the kind of roads over which the truck is travelling. In this experiment, the 2 h trucking was done on a good paved highway except for a circa one-half km stretch of gravel road leading from the Ranch to the main highway. Because of that, the cattle could stand easily, without having to constantly brace themselves against a fall. Trucking in this experiment was also done on a highway with very little traffic. That may also be a factor in the low impact of the truck ride on the cattle.

The only large increase in heart rate came when the animals were loaded onto the truck. Thereafter a gradual decrease was noted, which suggests that the animals were at

ease during the trucking. The increase in heart rate at loading may be due to the novelty of the truckbed environment. In a study using two to four month old Jersey calves, Stephens and Toner (1975) found that leading a calf (alone) onto a truck resulted in an increase in heart rate from 80 beats/min to 110 beats/min. But the rate soon dropped to 100 beats/min as the calves were allowed to accustom themselves to the truckbed. Heart rate dropped further to circa 60 beats/min when the calves became recumbant.

Similar results have been reported in a study done on the response of beef breed calves to transport related events (Stermer et al. 1981). It was found that average heart rate increased by circa 30 beats/ min when the calves were loaded on a vehicle. After 2 h transit, heart rate of calves was, on average, 18 beats/min over resting rate. But after 24 h transit, there was no elevation in heart rate. Unfortunately, Stermer et al. gave no information about the stocking density on the truck, the type of road over which the animals were transported, or the nature of the social groupings collected on the truck.

Serum cortisol assay revealed no significant differences in change of cortisol levels after handling and transport. But the results of the cortisol analysis requires some explanation and qualification. The generally higher serum cortisol levels of steers are most likely due to the altered steroid balance of castrated animals. Castration

probably leads to loss of feedback effects between the pituitary-adrenal and pituitary-gonadal axes (Deviche et al. 1981, Moberg 1983), and perhaps to deviations from normal steroid synthesis pathways (Brown 1978). But this should not affect the relative differences between cortisol levels before and after the treatment. However, Fulkerson et al. (1980) found that cattle show circadian and ultradian cycles in blood cortisol levels. Levels are generally high in the early morning and lowest in the afternoon. In this experiment, handling and trucking took place between 1000 h and 1400 h, a period of decreasing cortisol concentrations.

In the present study, the treatment given to the animals can be separated into two components. One component is the trucking itself, and the other is the handling of the cattle in the chute system before and after the trucking. The design of this experiment, with most measurements being spot values before and after transport, does not lend itself to the separation of these two components. However, the 10 min transport routine put most of the emphasis on the loading and handling component. The fact that steers showed somewhat greater increases in respiratory rate and cortisol level after the 10 min than the 2 h transport, leads one to think that the castrates found the loading and chute system handling to be more disturbing than the truck ride itself. This pattern is not evident in the data on bulls.

Nevertheless, the overall picture suggests that the reactions of yearling bulls and steers to trucking are

similar and minor. But since all responses of animals are due to the interaction of genetic and previous experience factors, generalizations should be made carefully. Studies with other species, for example, have shown more pronounced responses to handling and transport. Plasma corticosterone values of mice subjected to transport by truck or plane were higher than in non-stressed controls, and remained high for at least 48 h (Landi et al. 1982). Monitoring plasma corticosteroids levels via permanently indwelling catheters, Fenske et al. (1981) found that transport of pre-pubertal gilts for 50 km resulted in a significant increase in corticosteroid levels, with maximum concentration coming 100 minutes after transport by truck began. Furthermore, they found that truck transport led to greater increase in corticosteroids than electric shock treatment. In another study of pigs, "simulated transport" resulted in heart rate being elevated during the first 30 min (Stephens and Rader 1982). From a resting level of 110 beats/min, heart rate rose to 150 beats/min.

The social situation under which stress is experienced is also important. Presence of herd-mates may have a supportive effect on an animal's ability to cope with the novelty and uncertainty of trucking. In a study with sheep (*Ovis aries*), Kilgour and deLangen (1970) reported only slightly elevated plasma cortisol levels in sheep after trucking as a group. Interestingly, cortisol levels after trucking were much lower than after 10-15 min of shearing.

And the authors suggested that in sheep, any handling becomes much more stressful if the animal is separated from the flock (as in shearing). They also noted that elevation of blood cortisol levels after any handling is influenced by the experiences that an animal has had previously during similar handling. There is no reason to think that cattle are very different from sheep in this respect. In the present study, the animals were transported in socially stable pen units, which may have served to buffer the animals against the novelty of the trucking experience. Levine (1983) has argued that uncertainty and predictability are also important modifiers of behavioural and physiological response to any environmental stimulus. That should be kept in mind whenever cattle are likely to be transported or handled on a routine basis. Few responses of livestock are fixed. They are continually modified according to the nature of the animals' experiences

SYNTHESIS

The previous four chapters have dealt with separate experiments. However, their common aim was to clarify the differences in response of bulls and steers to normal beef cattle management and handling. The focus of the comparison was the problem of dark-cutting in beef carcasses. This condition of unacceptably dark, firm and dry meat which is the most frequently occurring quality deviation in beef (Eikelenboom 1981), is related to stress prior to slaughter, and seems to be particularly common among bulls.

Before the start of formal experimentation, it had been noticed that whenever bulls from several pens were combined for transport to an abattoir, the incidence of dark-cutting carcasses seemed to be higher. The first experiment confirmed that mixing unfamiliar bulls was an important cause of dark-cutting. Bulls were marketed either with pen-mates or with strangers, and held overnight at the abattoir. Those animals marketed with pen-mates, produced less than 2% dark-cutting whereas of those shipped with strangers, over 73% were dark-cutters. Also associated with regrouping was a greatly elevated level of aggressive behaviour.

The results of that study led me to ask whether simple management strategies could be devised to minimize the effect of regrouping bulls, and to ask how steers would respond to similar circumstances. Combining unfamiliar animals late in the evening, a period when social activity

typically has subsided (and in this case 12 h before slaughter), was compared with mixing animals the next morning (6 h before slaughter). This strategy produced 64% and 14% dark-cutting respectively among bulls. The same treatment applied to steers produced no dark-cutting, and established that bulls were more susceptible to the dark-cutting condition than steers.

Two normal husbandry practices, mixing unfamiliar animals, and transporting them to the abattoir, are both possible stressors. The comparative responses of bulls and steers to each of these treatments may explain their different susceptibility to dark-cutting. First, bulls and steers were transported by truck for either 10 min or 2 h. Transporting cattle involves changing their physical environment. In this experiment, both castes showed similar physiological and behavioural responses. Furthermore, their responses were not only similar, but also minor, probably because care was taken not to alarm the animals. Transport can severely affect both bulls and steers, but does not need to be stressful to either. There is no peculiarly intact male orientation to handling or to transport, unlike their reactions to females or competing males. I concluded that truck transport was not more stressful to bulls than to steers.

Second, bulls and steers were mixed with strangers at about nine, twelve and fifteen months of age. This led to more mounting and aggressive behaviour among bulls. But

there was a daily decrease in the rate of these behaviours. By the tenth day there was no significant difference in the rate of aggressive behaviour. Mounting, however, remained more common among bulls. In conclusion, I found that bulls reacted more vigorously to social disruption, and that differences between bulls and steers increased with age, from nine to fifteen months.

Clearly, the husbandry of bulls may necessitate some modification of practices which have been designed for steers. Bulls were more susceptible to dark-cutting. My results support suggestions that mixing bulls was an important stressor but that truck transport was not very stressful to the cattle. Regrouping unfamiliar bulls led to dark-cutting, probably because the animals fought to establish new rank relationships. Steers did not fight as much as bulls. Perhaps steers generally establish rank with fewer overt signs of rank having been contested. On the other hand, steers may simply not be as interested in dominance rank as bulls. An important role of dominance relationships among cattle is access to estrous females. In their natural state, cattle do not defend or often compete for food resources. Cows in estrus may be the only 'resource' for which bulls compete, and may be tended and 'protected' from other males. If castrated males are less motivated towards sexual goals, they may be less motivated to attain high social rank. Regrouped bulls also show more mounting than steers. Whether mounting is simply 'sexual

behaviour' or also contains an element of agonism, it would not be expected to occur as frequently among castrated animals with a presumably reduced sex drive.

The preceding study dealt with groups of eight animals in small pens. Large groups may be less socially stable than small ones. With that in mind, I observed the behaviour of bulls and steers in large commercial groups of over 200. Under these circumstances, bulls and steers showed behaviour differences that were not detected in small groups. Bulls were generally more active than steers. Bulls did slightly more bunting, but steers were more often seen gambolling about the pen. Gambolling is a behaviour pattern that was not seen at all among steers or bulls kept in groups of eight. Throughout the day, bulls did much more mounting than steers, and the repeated mounting of one or two bulls by several others was seen occasionally. I propose that the larger the group size, the greater the social behaviour differences between the two castes.

Furthermore, I propose two generalizations about the effects of castration on response to handling and on social behaviour. First, bulls will be more active than steers in situations where hormones are relevant (those in which the behaviour of adult males would influence their mating success). That includes agonistic interactions during temporary social disruption caused by regrouping, or chronic social disruption caused by very large group sizes. Second, steers seemed behaviourally less mature than bulls. Steers

did slightly more gambolling about in their pen, a typically calf-like behaviour. Perhaps steers retain juvenile behaviour patterns to a later age simply because there is no other adult male motivating drive with which to replace them.

Finally, it has also been the intent of this thesis to offer advice to the husbandryman. First, bulls should be kept in socially stable surroundings. They should not be regrouped before slaughter. If that is unavoidable, the mixing should be done several weeks before marketing. Second, social stability is influenced by group size. No specifics can be given as to the optimum number of bulls in a group, but the larger the group, the more likely it is that behavioural problems will arise, and the more husbandry input the manager must be prepared to make. Third, truck transport of bulls poses no special problems. Responses of bulls will likely be similar to those of steers. How the cattle react, therefore, is largely a function of how well the handlers do their job, rather than of the androgen levels of the animals. Fourth, differences in social behaviour between bulls and steers increased from age nine months to fifteen months. Behavioural problems may escalate if bulls are kept to a later age in feedlot conditions.

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APPENDIX 1: DARK-CUTTING BEEF, THE METABOLIC PROCESS

In cattle, pre-slaughter stressors have been found to lead to an increased incidence of dark-cutting beef (Chapter I). What metabolic processes are responsible for this discolouration? How does a psycho-physiological change of state produce a biochemical alteration in the meat? To properly explain stress induced biochemical changes that give rise do dark-cutting carcasses, it is first necessary to understand what happens in the normal, unstressed animal. Dark-cutting beef is a result of the depletion of muscle glycogen stores (Thompson 1974). Glycogen is a branched polysaccharide made up of numerous glucose molecules. Glycogen is the form in which animals store carbohydrates, and in vertebrates, it occurs primarily in liver and muscle.

Muscle cells, as do other cells of the body, require energy to survive. Although the immediate source of energy in cells is in the form of the potential energy of adenosine triphosphate (ATP), the supplies of ATP are so small as to only meet normal energy reguirements for a few minutes (Hultman et al. 1974). As a result, ATP must continuously be resynthesized. Resynthesis requires fuel energy. Normally, fuel energy needs of respiring animals are met by the catabolism of circulating blood glucose. This catabolic pathway conserves energy (i.e. ATP molecules are produced). But although blood glucose concentration may be high following a meal rich in sugar, circulating blood glucose is an ephemeral entity. Therefore, its level must be regulated.

That function is carried out by the liver glycogen depot (Hultman et al. 1974).

In the liver, glycogen is broken down into its glucose constituents. Through the reactions of glycolysis, glucose is transformed to pyruvic acid. Under aerobic conditions the the pyruvic acid is transported to the mitochondria, transformed to Acetyl CoA and enters the TCA cycle, finally exiting as water and CO_2. If oxygen is not present (as for example during exertion when muscle cells have built up an oxygen debt), pyruvic acid is transformed to to lactic acid. The lactic acid diffuses out of the cells and is carried by venous circulation to the liver. It is here that most glucose resynthesis takes place. The glucose synthesized in the liver is transported arterially back to muscles where it can again undergo glycolysis. But the cycle is not 100% efficient, and therefore some dietary input of carbohydrate is needed to maintain adequate glycogen stores. Muscle is also a storage depot for glycogen. However, muscle glycogen breakdown takes place within the cells, and serves only as a local energy source. The process that leads to glycogen breakdown can be initiated by (1) a muscle contraction stimulus, or (2) adrenalin release. Hard exercise will stimulate a faster rate of glycogenolysis than that resulting from adrenalin release alone (Hultman et al. 1974). Both can result from improper pre-slaughter handling and management techniques.

As mentioned, both psychological stressors and physical exhaustion due to hard exercise will lead to glycogenolysis. And glycogen depletion has been established as the causative factor in dark-cutting beef. How then does glycogen depletion affect the process of post-mortem metabolism?

When an animal is slaughtered, all its metabolic functions do not suddenly stop. The conversion of muscle to meat can take from several minutes to days (Forest et al 1975). Of course one very important event at slaughter is the exsanguination of the animal. With no cirulatory system to ferry substrate materials and enzymes from site to site, metabolic reactions either take place in situ or they do not take place at all. The disappearance of oxygen carrying blood also means that for all intents and purposes, post-mortem muscle metabolism is anaerobic. The most obvious post-mortem changes are stiffening and loss of extensibility of the muscles. This is normally accompanied by the loss of glycogen and ATP, the production of lactic acid, and drop in pH (Bendall 1973). ATP acts as an elasticizer of muscle, and its loss is the event most closely linked to the onset of rigor mortis (Bendall 1973). Anaerobic metabolism in muscle tissue after death will produce 2 molecules of ATP, 2 molecules of lactic acid, and 2 hydrogen ions for every molecule of glucose that enters the pathway (Lehninger 1975). If glycogen stores are high as in a rested, well-fed animal, the post-mortem process of breaking down the glycogen will be prolonged. During the glycolysis, ATP is

produced which will prevent full rigor mortis. And because the products of glycolysis (lactic acid, protons) cannot be removed from the muscle, there is build up of these products. That generally leads to an important fall in pH from pH 7 to pH 5.5 in full rigor (Bendall 1973). However, if glycogen stores have been exhausted before slaughter, then there is little further glycogenolysis that can take place in the muscle (or elsewhere). As a result, there is much less production of lactic acid and hydrogen ions and therefore much less fall in pH. Also, because of reduced glycolysis, less ATP is formed and rigor mortis sets in more quickly (Bendall 1973).

Ultimate pH of the meat, then, depends on glycogen reserves of the muscle at time of exsanguination. But it is colour and texture that identify dark-cutting beef. How does high pH lead to dark colour? The predominant colour pigment of muscle and meat is myoglobin. It consists of 80-90% of total pigment (Forest et al. 1975). When the animal is alive and well supplied with oxygen, myoglobin is in its oxymyoglobin form, responsible for the bright colour associated with fresh meat. But during typical post-mortem enzyme activity, any oxygen in the muscles is used up, and myoglobin is changed to its reduced form, metmyoglobin which is a dark purplish-red colour (Forest et al. 1975). In normal meat (in this context meat with pH less than about 5.9), a fresh cut is dark at first, but becomes the desired bright red colour as the metmyoglobin changes to

oxymyoglobin. But since dark-cutting beef is at a higher than normal pH, it is above the iso-electric point of normal muscle. That results in more water being held intracellularly, thereby making the muscle fibers turgid and more tightly packed. How does this change meat colour? There is agreement that the change in colour has to do with altered reflectance of light. But there is disagreement as to whether the turgid cells reflect less light and therefore appear darker (Forest et al. 1975), or if meat of higher pH is simply more translucent, allowing us to look deeper into the meat, thereby darkening the usual red colour (Bendall 1973). In any case the condition is cosmetic, and dark-cutting beef contains no abnormal compounds (Thompson 1974).

APPENDIX 2: DISCRIMINANT FUNCTION ANALYSIS

	Function 1	Function 2
A. Standardized Canonical Discriminant Function Coefficients		
Fighting	-0.2568	1.1756
Flehmen	0.7931	0.0316
Mounting	0.6419	-0.6852
Cribbing	-0.3029	-0.4241
Percent of Variance Explained	63.22	28.55
B. Canonical Discriminant Functions Evaluated at Group Means		
B9	0.3881	0.9973
B12	1.4064	-0.2879
B15	0.1474	-0.5665
S9	-0.5630	-0.5665
S12	-0.7110	-0.1413
S15	-0.6730	-0.2400

APPENDIX 3: THYROID AND ADRENAL DATA

	T_3	THYROXINE	WEIGHT OF ADRENAL GLANDS (g)
BULLS	9.8±.72	0.6±.11	17.3±.64
STEERS	10.1±.97	0.8±.28	15.0±.62
	p=.994	p=.499	p=.013 *

* When analyzed as adrenal gland weight per kg of body weight, the difference is non-significant (p=0.382).